Einfluss ikonischer Gesten auf das Wortlernen von Kindern mit und ohne umschriebene Sprachentwicklungsstörung: Eine Trainingsstudie

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Zusammenfassung

Die vorliegende Dissertation beschäftigt sich mit dem Einfluss sprachbegleitender ikonischer Gesten auf das Wortlernen bei Vorschulkindern. Ikonische Gesten gelten als förderlich für das Erlernen neuer Wörter, weil sie Bedeutungsmerkmale des Referenten abbilden und so möglicher Weise die Verarbeitung des sprachlichen Inputs und die Speicherung der Wörter erleichtern. Dies könnte insbesondere Kindern mit umschriebenen Sprachentwicklungsstörungen (USES) von Nutzen sein, die neben anderen sprachlichen Einschränkungen häufig auch Schwierigkeiten beim Wortschatzerwerb zeigen. Zwar wird der positive Effekt ikonischer Gesten auf das Wortlernen zunehmend evident. Allerdings lassen sich die bisherigen Forschungsergebnisse nur eingeschränkt generalisieren und auf Kinder mit USES übertragen.

Im Rahmen dieser Dissertation wurde deshalb eine Trainingsstudie mit Vorschulkindern mit und ohne USES durchgeführt. In dieser wurde untersucht, ob die Kinder vom Angebot sprachbegleitender ikonischer Gesten für das Lernen neuer Wörter profitieren. Als Kontrollbedingung wurde eine Geste gewählt, die keine Bedeutungsinformationen enthält, sondern die Aufmerksamkeit auf die neuen Wörter lenkt. Das Wortlernen wurde als Prozess über einen Zeitraum und mittels unterschiedlicher Aufgaben erfasst.

Die Ergebnisse zeigen einen Vorteil ikonischer Gesten gegenüber aufmerksamkeitslenkenden Gesten. Ikonische Gesten beeinflussten das Wortlernen bei Kindern mit USES und typisch entwickelten Kindern positiv. Sie unterstützten den Aufbau der Verbindung einer lexikalischen Form mit einer Bedeutung und deren längerfristige Speicherung. Mehr noch als typisch entwickelte Kinder machten Kinder mit USES von ikonischen Gesten Gebrauch, um die Wortbedeutungen zu durchdringen und Bedeutungswissen aufzubauen.

Die im Rahmen dieser Dissertation gewonnen Ergebnisse ergänzen und erweitern das vorhandene Wissen darüber, wie sprachbegleitende ikonische Gesten das Wortlernen von Kindern mit und ohne USES beeinflussen und begünstigen. Sie zeigen, dass ikonische Gesten mehr als andere Gestenarten das Potenzial haben, das Wortlernen zu unterstützen. Und sie machen deutlich, dass insbesondere sprachauffällige Kinder von den zusätzlichen visuellen Informationen profitieren, die die Gesten ihnen bieten. Daher sollten Gesten generell, und ganz besonders ikonische, in der Sprachtherapie und der Sprachförderung eingesetzt werden.

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Aufbau dieser Dissertation

Kinder mit Sprachentwicklungsstörungen zeigen neben Problemen mit der Grammatik und der Aussprache häufig auch Schwierigkeiten beim Erlernen von Wörtern. Als eine mögliche methodische Herangehensweise zur Verbesserung des Wortlernens wird in der Literatur das Anbieten ikonischer Gesten parallel zum sprachlichen Input genannt. Allerdings gibt es nur wenige Untersuchungen, die diese Annahme belegen.
Im Rahmen dieser Dissertation wurde in einer Trainingsstudie untersucht, ob sprachauffällige und typisch entwickelte Vorschulkinder vom zusätzlichen Input ikonischer Gesten für das Lernen neuer Wörter profitieren. Die Kinder erlernten in einem Training neue Wörter. Das Wortlernen wurde anschließend mit den Aufgaben Verstehen, Benennen und Definieren der Zielwörter überprüft.

Die Dissertation gliedert sich in zwei Teile.
Teil I beinhaltet die Synopse der Studie. Hier werden der Hintergrund der vorliegenden Arbeit, abgeleitete Desiderata und Ziele, das methodische Herangehen und die wesentlichen Ergebnisse der Studie zusammengefasst und diskutiert. Abschließend werden Implikationen für die Sprachtherapie erörtert und ein Ausblick auf weitere Forschung gegeben.
Teil II umfasst drei wissenschaftliche Artikel, in denen die Ergebnisse der Outcomemaße (abhängige Variablen) Benennen und Verstehen, Benennen mit und ohne Abrufhilfen und Definieren der neu erlernten Wörter vorgestellt und diskutiert werden.

I Synopse

Theoretischer und empirischer Hintergrund

Der Erwerb von Wortschatz ist ein essentieller Bestandteil der kindlichen Sprachentwicklung. Dem Kind stellt sich dabei eine komplexe Aufgabe. Es muss eine neue Wortform (Silben, Phoneme) im sprachlichen Angebot erkennen und diese mit einer Bedeutung in Verbindung bringen (fast mapping; Carey, 1978). Den initialen Lexikoneintrag muss es in verschiedenen Kontexten zunehmend ausdifferenzieren und das neue Wort im mentalen Lexikon organisieren, verknüpfen und verankern (slow oder extended mapping; He & Arunachalam, 2017; Horst & Samuelson, 2008; Kauschke, 2003). Je elaborierter und strukturierter das Lexikon aufgebaut ist, desto besser gelingt der Zugriff auf Lexikoneinträge (Rothweiler, 2001). Einen umfangreichen und breit gefächerten Wortschatz aufzubauen ist wesentlich für die weitere sprachliche Entwicklung und die Grundlage, um erfolgreich zu kommunizieren und zu lernen (Glück & Spreer, 2015; Gray & Brinkley, 2011; McGregor, Oleson, Bahnsen & Duff, 2013).

Wortlernen bei Kindern mit USES

Für Kinder mit einer umschriebenen Sprachentwicklungsstörung (USES) kann der Wortschatzerwerb eine große Herausforderung darstellen (Gray, 2004; Nation, 2014). Eine USES ist eine Beeinträchtigung des Spracherwerbs, die nicht auf sensorische, organische, mentale oder gravierende sozio-affektive Defizite zurückgeführt werden kann. Die Prävalenz wird mit 5 bis 8 % angegeben, Jungen sind häufiger als Mädchen betroffen (Bishop, 2014; Langen-Müller, Kauschke, Kiese-Himmel, Neumann & Noterdaeme, 2011). Die Symptomatik stellt sich sehr heterogen dar. Neben Auffälligkeiten in der Grammatik und Phonologie sind Störungen des Lexikons und der Semantik Teil der mit USES assoziierten Charakteristika.

Die Problematik von Kindern mit einer lexikalisch-semantischen Störung betrifft quantitative Aspekte (Wie viele Wörter kennen die Kinder?) wie auch qualitative (Wie gut kennen die Kinder die Wörter?) (Nation, 2014). Einerseits fällt den Kindern das lexikalische Lernen schwer, d.h. die Verknüpfung einer lexikalischen Form mit einer Bedeutung. Dies führt zu einem eingeschränkten Umfang des rezeptiven und expressiven Wortschatzes und der lexikalischen Vielfalt (auch als Wortschatzbreite bzw. vocabulary breadth bezeichnet) gemessen an typisch entwickelten Kindern (typically developing: TD) gleichen Alters. Gleichzeitig haben sie Schwierigkeiten bei der Aneignung von Wissen über die Wortbedeutung (Wortschatztiefe bzw. vocabulary depth). Sowohl das fast

mapping wie das slow mapping sind betroffen. Der Erwerb von Verben fällt gegenüber dem Nomenerwerb besonders schwer (Alt, Plante & Creusere, 2004; Kan & Windsor, 2010). Insgesamt zeigen Kinder mit USES Wortschatz- und Wortlernfähigkeiten, die mit denen von jüngeren TD Kindern vergleichbar sind. (Für einen Überblick siehe Kan & Windsor, 2010, Kauschke & Rothweiler, 2007, und Nation, 2014). Häufig wird angenommen, dass sich lexikalisch-semantische Störungen in eingeschränktem Verstehen und Benennen von Wörtern manifestieren und dass diese Defizite auf unzureichenden semantischen Repräsentationen basieren (McGregor, Newman, Reilly & Capone, 2002; Nash & Donaldson, 2005; Nation, 2014). Da bei vielen Kindern mit einer USES Defizite bestehen bleiben und sich sogar noch ausweiten (McGregor et al., 2013; Stothard, Snowling, Bishop, Chipchase & Kaplan 1998), sind frühzeitige und effektive Interventionsmaßnahmen geboten.

Ikonische Gesten als Ressource für das Wortlernen

Als ein möglicher Ansatz, das Wortlernen von Kindern mit USES zu unterstützen, gilt das Präsentieren ikonischer Gesten parallel zum Angebot neuer Wörter (Botting, Riches, Gaynor & Morgan, 2010; Capone, 2007, Lüke, Rohlfing & Stenneken, 2011). Ikonische Gesten sind beobachtbare Bewegungen von Körperteilen, meist der Hände, die Bedeutungsaspekte der durch die Geste übermittelten Entität aufgreifen. Sie repräsentieren Objekte, Ereignisse oder Zustände durch ihren visuell-räumlichen Bezug zum Referenten (McNeill, 1992; Novack, Goldin-Meadow & Woodward, 2015; Özyürek, 2000), wie z.B. seitliches Flattern mit den Händen als Verweis auf den Referenten *Vogel* bzw. *fliegen*. Kinder sind ab dem Alter von zwei Jahren in der Lage, von ikonischen Gesten zu lernen und erfassen mit vier Jahren deren Bedeutung (Novack et al., 2015; Tolar, Lederberg, Gokhale & Tomasello, 2008). Zuerst verstehen und produzieren sie ikonische Gesten, die eine Handlung aufgreifen, z.B. fliegen, und danach erst Gesten, die die Form eines Objekts abbilden, z.B. die Hörner einer Antilope (Hodges, Özçalişkan & Williamson, 2015; Tolar et al., 2008). Dieser Ansatz zielt auf eine verbesserte Speicherung neuer Wörter und eine Erweiterung der semantischen Repräsentationen aufgrund der visuell-räumlichen Hinweisreize zusätzlich zum verbalen Input ab.

Tatsächlich wird ein positiver Effekt sprachbegleitender ikonischer Gesten auf lexikalische und semantische Aspekte beim Wortlernen zunehmend evident. So zeigen Studien mit TD Kindern (Capone & McGregor, 2005; McGregor, Rohlfing, Bean, & Marschner, 2009; Mumford & Kita, 2014) und mit Kindern mit USES (Ellis Weismer & Hesketh, 1993; Lüke & Ritterfeld, 2014), dass das gleichzeitige Angebot ikonischer Gesten und neuer

Wörter das Wortlernen im Vergleich zum rein verbalen Input der Wörter verbesserte. Außerdem unterstützen ikonische Gesten das Wortlernen junger TD Kinder effektiver als andere Gestenarten. Dies wurde gezeigt für Zeigegesten (Capone Singleton, 2012) und für arbiträre Gesten, die keinen visuellen Bezug zum Referenten aufweisen (Marentette & Nicoladis, 2011; Namy, Campbell & Tomasello, 2004).

Die bisherigen Forschungsergebnisse zum Einfluss ikonischer Gesten auf das Wortlernen lassen sich allerdings nur bedingt generalisieren und auf Kinder mit USES übertragen. Zum einen wurde häufig Wortlernen mit und ohne ikonische Gesten verglichen. Damit beinhaltete die Kontrollbedingung – im Unterschied zur ikonischen Gestenbedingung - neben dem verbalen Input keine weiteren Hinweisreize, und es bleibt offen, ob die Kinder von der spezifischen ikonischen Information der Geste oder allgemein von einer erhöhten Aufmerksamkeit aufgrund eines zusätzlichen visuellen Reizes profitierten. Zum anderen untersuchten viele Studien lediglich die vorläufige Zuweisung einer lexikalischen Form zu einer Bedeutung. Um die Komplexität und den Prozess des Wortlernens abzubilden, ist aber zusätzlich zur Untersuchung des fast mappings die Erfassung des Bedeutungswissens und der Qualität der Verankerung des neuen Lexikoneintrags (slow mapping) erforderlich. Überdies waren die in den Studien verwendeten Zielitems (z.B. Pseudowörter für Nomen und Präpositionen, Eigennamen) wenig repräsentativ für die Wörter und Wortarten, die Kinder erwerben. Die Mehrzahl der Studien schloss außerdem nur TD Kinder ein, obwohl gerade bei Kindern mit USES Sprache und Gesten besonders eng zusammen zu hängen scheinen (Botting et al., 2010; Kirk, Pine & Ryder, 2011). Die raren Studien mit USES Populationen umfassten geringe Gruppengrößen und verglichen die sprachauffälligen Kinder lediglich mit altersgleichen TD Kindern. Um Lernmuster untersuchen bzw. vergleichen zu können, ist es allerdings angebracht, zusätzlich eine hinsichtlich der sprachlichen Fähigkeiten vergleichbare TD Gruppe einzubeziehen.

Die vorliegende Arbeit greift diese Forschungslücke auf. Hauptziel der Studie war es daher, den relativen Einfluss ikonischer Gesten (im Vergleich zu einer Kontrollgestenbedingung) auf das Erlernen substantieller Wortarten (Nomen und Verben) bei Vorschulkindern mit USES und einer Störung der lexikalisch- semantischen Ebene auf das fast mapping und slow mapping zu untersuchen. Dabei sollten quantitative und qualitative Aspekte des Wortwissens erfasst werden. Die Kinder sollten außerdem mit einer TD Gruppe im gleichen chronologischen Alter und mit einer Gruppe jüngerer, hinsichtlich sprachlicher Fähigkeiten vergleichbaren Gruppe verglichen werden.

Methode

Zur Untersuchung des relativen Einflusses ikonischer Gesten auf das Wortlernen wurde eine Trainingsstudie unter Verwendung eines Mixed Designs durchgeführt. Die Datenerhebung fand in den Regionen Frankfurt/Main und Hamburg statt. Die Ethikkommission der Hochschule Fresenius hatte dem Antrag zur ethischen Vertretbarkeit des Forschungsvorhabens zugestimmt (Mitteilung der Kommission vom 10.05.2013).
Das methodische Vorgehen wird im Folgenden zusammengefasst. Ausführliche Darstellungen finden sich in den anhängenden Publikationen (Teil II).

Untersuchungsteilnehmer

In die Studie wurden insgesamt 60 monolingual mit Deutsch aufwachsende Kinder aufgenommen:

a) 20 Kinder mit einer USES und einem Störungsschwerpunkt auf der semantisch-lexikalischen Ebene (10 Jungen, 10 Mädchen, Durchschnittsalter 4;6 Jahre),
b) 20 zu den Kindern mit USES nach Alter und Geschlecht parallelisierte sprachgesunde Kinder (Alters-Match, AM; Durchschnittsalter 4;5 Jahre) und
c) 20 jüngere, hinsichtlich ihrer Wortschatzfähigkeiten vergleichbare sprachgesunde Kinder (Sprach-Match, SM; 9 Jungen, 11 Mädchen, Durchschnittsalter 3;3 Jahre).

Vorgehen

In einer Trainingsstudie wurden den Kindern neue Wörter unter zwei Lernbedingungen beigebracht (within-subjects Design). In einer Voruntersuchung (T0) wurde neben nonverbalen kognitiven und sprachlichen Fähigkeiten auch untersucht, inwieweit die Kinder die zu erlernenden Zielitems kannten. Anschließend fanden drei Trainingssitzungen à 30 Minuten statt, in denen den Kindern die Zielitems präsentiert wurden. Das Wortlernen wurde im Anschluss an die erste Sitzung (T1) und 2-3 Tage nach Abschluss des Trainings (T2) untersucht (Abbildung 1). Alle Untersuchungen und Trainingssitzungen fanden im Einzelsetting in einem Extraraum im Kindergarten statt.

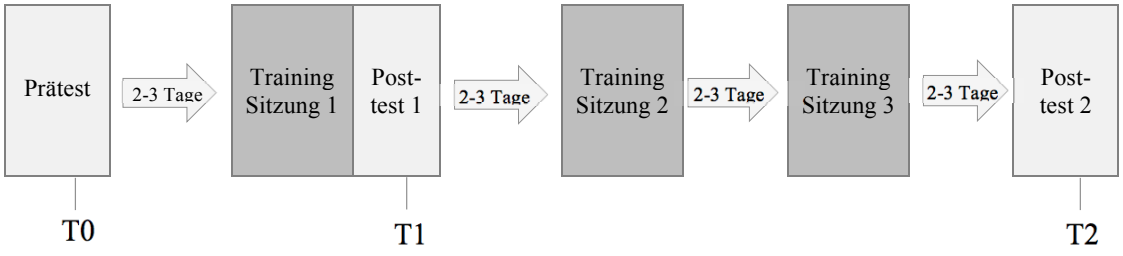

Abb. 1. Studiendesign (Training und Messzeitpunkte)

Zielitems

Als Zielitems wurden je sechs niedrigfrequente Nomen und Verben des Deutschen ausgewählt. Die Nomen bezeichneten seltene Tierarten (die Ralle, die Gopher, die Beisa, der Alk, der Fennek, der Numbat), die Verben waren transitiv und repräsentierten ungewöhnliche Bewegungsarten (staksen, retschen, hüpeln, tippeln, krauchen, gliddern). Alle Zielitems waren in einer Vorstudie auf ihre Verwendbarkeit in einem Wortlerntraining bei Vorschulkindern getestet worden. (Für eine detaillierte Übersicht über die Zielwörter mit ihren Bedeutungsmerkmalen, den verwendeten Abbildungen sowie den jeweiligen Gesten siehe Teil II, Artikel 3, Tabelle 2).

Eine Pilotstudie hatte gezeigt, dass vier- und fünfjährige TD Kinder problemlos zwölf Wörter innerhalb dreier Sitzungen erlernen können, dies allerdings bei gleichaltrigen Kindern mit USES und jüngeren TD Kindern zu Aufmerksamkeitseinbußen während des Trainings und zu Bodeneffekten in den Posttests führt. Um Decken- bzw. Bodeneffekte zu vermeiden, wurden den älteren TD Kindern zwölf neue Wörter beigebracht, den Kindern mit USES und den jüngeren TD Kindern acht neue Wörter. Entsprechend werden die Outcomewerte in Prozent- bzw. Verhältniswerten angegeben.

Lernbedingungen

Die Zielitems wurden den Kindern in zwei Gestenbedingungen präsentiert. In der ikonischen Gestenbedingung (IKON) wurden die gesprochenen Zielwörter immer gleichzeitig mit einer ikonischen Geste präsentiert, die ein Formmerkmal des jeweiligen Tieres bei Nomen (z.B. die Hörner der *Beisa*) bzw. die Art und/oder Richtung der Bewegung bei Verben (z.B. die Rückwärtsbewegung beim *Retschen*) verdeutlichte. In der Kontrollbedingung (AUFM) wurden die gesprochenen Zielwörter mit einer (immer gleichen) aufmerksamkeitslenkenden Geste in Form eines erhobenen Zeigefingers auf Höhe des Brustbereichs der Untersucherin präsentiert. Die Hälfte der Zielwörter (jeweils zur Hälfte Nomen bzw. Verben) wurden in der IKON Gestenbedingung, die andere Hälfte (auch hier je zur Hälfte Nomen und Verben) in der AUFM Gestenbedingung dargeboten.

Training

Das Training folgte einem standardisierten Ablauf. Die Zielitems waren in eine Geschichte eingebunden. Sie wurden in der ersten Trainingssitzung eingeführt (je 20 Präsentationen) und in den beiden weiteren Sitzungen (je 20 bzw. 17 Präsentationen) wiederholt, insgesamt 57 Mal, immer parallel entweder mit einer ikonischen oder einer aufmerksamkeitslenkenden Geste. Jede Trainingssitzung bestand aus drei Phasen. Zuerst

wurde den Kindern die Geschichte vorgelesen. In einem anschließenden Übungsspiel wurden den Kindern mittels Modellierungstechniken Bedeutungsmerkmale der Zielitems vermittelt, z.B. bzgl. des Lebensraums und Futters der Tiere bzw. der Ausführung und Funktion der Bewegungen. Den Abschluss bildete das gemeinsame Betrachten eines Videos auf einem Tabletcomputer durch Kind und Untersucherin, in der eine Schauspielerin die Geschichte mit den entsprechenden Gesten erzählt.

Untersuchung des Wortlernens

Um das Wortlernen als Prozess im Zeitverlauf und hinsichtlich unterschiedlicher Dimensionen zu untersuchen, wurden die kindlichen Fähigkeiten an drei Messzeitpunkten und mittels mehrerer Outcomemaße (abhängige Variablen) erfasst (Tab. 2). Das Vorgehen war in einer Pilotstudie erprobt und anschließend leicht modifiziert worden.

- Messzeitpunkt 1 (T0: Prätest)

  Durch die Untersuchung des Wortverstehens (Wort-zu-Bild Zuordnung) und der Wortproduktion (Benennen) beim ersten Messzeitpunkt sollte gewährleistet werden, dass die Kinder die zu erlernenden Wörter nicht kannten.
- Messzeitpunkt 2 (T1: Posttest 1)

  Der erste Postmesszeitpunkt diente der Untersuchung des fast mapping. Dies wurde mittels je einer Aufgabe zur Wortproduktion (Benennen der Zielitems) und zum Wortverstehen (Wort-zu-Bild Zuordnung) operationalisiert.
- Messzeitpunkt 3 (T2: Posttest 2)

  Der zweite Postmesszeitpunkt galt der Überprüfung der slow mapping Fähigkeiten (Speicherung der Verbindung von lexikalischer Form und Bedeutung und Aufbau von Bedeutungswissen). Wie beim ersten Postmesszeitpunkt wurde je eine Aufgabe zur Wortproduktion (Benennen der Zielitems) und zum Wortverstehen (Wort-zu-Bild Zuordnung) durchgeführt. Die Aufgabe zur Wortproduktion wurde ergänzt: Gelang den Kindern das Benennen der Zielitems nicht, wurde ihnen die jeweilige Geste (mit der zusammen das gesprochene Zielwort während des Trainings immer präsentiert worden war) mit der Aussage „Schau mal: wir haben *so* gemacht“ als Hinweisreiz gezeigt. In der IKON Lernbedingung waren das die für die Zielitems spezifischen ikonischen Gesten, in der AUFM Lernbedingung die immer gleichbleibenden aufmerksamkeitslenkenden Gesten. Zur Untersuchung des Bedeutungswissens diente die Aufgabe, die Zielwörter zu definieren.

Tab. 1. Operationalisierung des Wortlernens: Messzeitpunkte, Funktion im Wortlernprozess, Outcomevariablen sowie die darauf Bezug nehmenden Artikel im Anhang

Messzeitpunkt	T0 2-3 Tage vor Trainingsbeginn	T1 unmittelbar nach Trainingssitzung 1	T2 2-3 Tage nach Trainingsabschluss	Inhalt welchen Artikels (Teil II)
Funktion im Wortlernprozess	Prätest	Fast mapping: schnelles Zuweisen von Wortform und Bedeutung (lexikalisches Lernen)	Slow mapping: Speichern der Verbindung Wortform und Bedeutung (lexikalisches Lernen) und Ausdifferenzieren der Bedeutung (semantisches Lernen)	
Outcomemaß	Operationalisierung			
Wortverstehen	Wort-Bild-Zuordnung	Wort-Bild-Zuordnung	Wort-Bild-Zuordnung	1
Wortproduktion	Benennen der Zielitems	Benennen der Zielitems	Benennen der Zielitems	1
			Benennen der Zielitems mit Geste als Hinweisreiz bei Nicht- bzw. Fehlbenennung	2
Bedeutungswissen			Definieren der Zielitems	3

Auswertung

Die Reaktionen der Kinder wurden hinsichtlich ihrer Korrektheit ausgewertet. Aufgrund der unterschiedlichen Anzahl der im Training präsentierten Zielitems (12 bei den älteren TD Kindern, acht bei den jüngeren TD und den Kindern mit USES) wurden die Werte als Prozentwerte bzw. relative Werte angegeben.

- Wortverstehen (Wort-Bild Zuordnung):
  Pro korrekt gezeigtem Zielitem erhielten die Kinder je einen Punkt (max. 12 bzw. acht). Die Summenscores wurden in Prozentwerte übertragen.
- Wortproduktion (Benennen der Zielitems):
  Die Kinder erhielten für jedes korrekt benannte Zielitem je einen Punkt (max. 12 bzw. acht). Die Summenscores wurden in Prozentwerte übertragen. Die Auswertung erfolgte in zwei Varianten: einmal ohne und einmal mit der Geste als Hinweisreiz.
- Bedeutungswissen (Definieren der Zielitems):
  Für jede zu den Zielitems gegebene angemessene Bedeutungsinformation wurde ein Punkt vergeben. Alle Punkte wurden zusammengezählt und durch die Anzahl der

erlernten Zielitems geteilt, so dass sich ein durchschnittlicher Informationswert pro Zielitem ergab. Bei den Nomen wurden nur verbale Informationen gezählt; bei den Verben wurde das korrekte Ausagieren der jeweiligen Bewegung als angemessene Bedeutungsinformation gewertet.

Datenanalyse

Die Daten wurden varianzanalytisch analysiert. Es wurden mixed-design ANOVAs mit den unabhängigen Variablen Messzeitpunkt (T0, T1, T2), Gestenbedingung (IKON, AUFM) und Wortart (Nomen, Verben) als within-subject Faktoren und Gruppe (USES, SM, AM) als between-subjects Faktor hinsichtlich der folgenden Outcomemaße (abhängige Variablen) durchgeführt:

- Quantitative Aspekte: Breite des Wortwissens:
  Wortverstehen: Anzahl korrekt gezeigter Zielitems (Prozentwerte)
  Wortproduktion
    - Anzahl korrekt benannter Zielitems (Prozentwerte)
    - Anzahl korrekt benannter Zielitems nach Geste als Hinweisreiz (Prozentwerte)

  Bedeutungswissen: Anzahl definierter Wörter (Prozentwerte)
- Qualitative Aspekte: Tiefe des Wortwissens:
  Bedeutungswissen: Anzahl von Bedeutungsinformationen pro Zielwort

Ergebnisse

Die Ergebnisse werden hinsichtlich der Gesamtleistung, der Gestenbedingung sowie der Wortart dargestellt. In Bezug auf die Gesamtwerte werden hier nur die Kinder mit USES und die jüngeren, hinsichtlich der Sprachfähigkeiten parallelisierten TD Kinder verglichen, denen im Training dieselbe Anzahl an Zielitems präsentiert worden war.

Quantitative Aspekte: Breite des Wortwissens

Wortverstehen

Bei allen Gruppen (USES, SM, AM) verbesserte sich kontinuierlich die Fähigkeit, die Zielwörter zu verstehen. Die Verstehensleistung der Kinder mit USES unterschied sich zum ersten Postmesszeitpunkt nicht von der der SM Kinder. Beim zweiten Postmesszeitpunkt schnitten die SM Kinder besser ab.

Nomen wurden beim ersten Postmesszeitpunkt von beiden TD Gruppen besser als Verben verstanden, bei Kindern mit USES unterschieden sich die Verstehensleistungen bezogen auf die Wortart nicht. Beim zweiten Postmesszeitpunkt verstanden die Kinder mit USES und die jüngeren TD Kinder Nomen besser als Verben, bei den altersgleichen TD Kindern gab es keinen Unterschied.

Die Kinder aller drei Gruppen zeigten eine bessere Verstehensleistung, wenn sie die Zielwörter mit ikonischen Gesten anstatt mit aufmerksamkeitslenkenden Gesten erlernt hatten. Der Effekt bezog sich auf Nomen und Verben zu beiden Postmesszeitpunkten gleichermaßen. In einem zusätzlichen Experiment mit 18 TD Vierjährigen wurde die Kontrollbedingung (aufmerksamkeitslenkende Gesten) verändert. Die ikonischen Gesten aus der Hauptstudie wurden nun mit derselben Anzahl an itemspezifischen, dynamischen arbiträren Gesten verglichen, die keine Ähnlichkeit mit den jeweiligen Referenten aufwiesen. Die Kinder zeigten zu beiden Postmesszeitpunkten bessere Verstehensleistungen bei den mit ikonischen Gesten erlernten Zielwörtern. Zwar wurde aufgrund des geringen Stichprobenumfangs der deskriptive Vorteil der ikonischen Gestenbedingung nicht statistisch signifikant; die Ergebnisse weisen aber in dieselbe Richtung wie im Hauptexperiment.

Wortproduktion

Auch bei der Wortproduktion zeigte sich ein stetiger Lernzuwachs: zu jedem Messzeitpunkt benannten die Kinder aller Gruppen die Zielwörter besser als zum jeweils vorherigen Messzeitpunkt. Die USES Gruppe unterschied sich in ihrer Benennleistung

zum ersten Postmesszeitpunkt nicht von der SM Gruppe. Beim zweiten Postmesszeitpunkt benannten die SM Kinder die Zielitems jedoch besser als die Kinder mit USES.

Die Benennfähigkeit bei Nomen und Verben unterschied sich nicht.

Die Benennleistungen waren zu beiden Postmesszeitpunkten bei den mit ikonischen Gesten erlernten Zielwörtern besser als bei den mit aufmerksamkeitslenkenden Gestern erlernten. Allerdings zeigte sich ein Einfluss der Gestenbedingung hinsichtlich des Messzeitpunkts auf die jeweilige Wortart der Zielitems: Zu T1 benannten die Kinder die mit ikonischen Gesten erlernten Verben besser als die mit der aufmerksamkeitslenkenden Geste erlernten Verben, aber nicht die Nomen. Zu T2 hingegen wurden die mit ikonischen Gesten erlernten Nomen besser benannt, nicht aber die Verben. Dieser Effekt betraf alle drei Gruppen gleichermaßen, d.h. Kinder mit USES reagierten auf die Gestenbedingungen ähnlich wie die TD Kinder. Die Gruppen sind deshalb bei der Darstellung des Effekts in Abbildung 2 zusammengefasst.

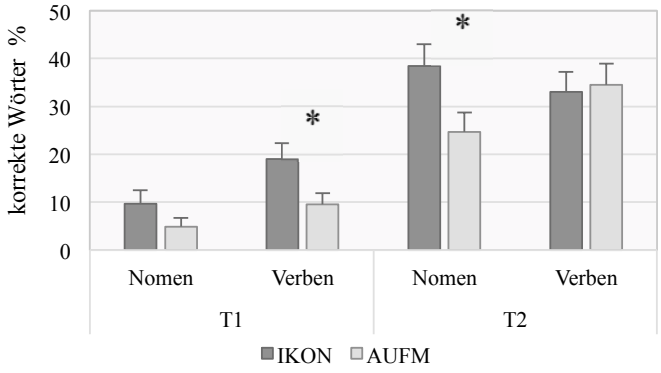

Abb. 2. Anteil korrekt benannter Zielitems (Mittelwerte und Standardfehler) je Wortart (Nomen, Verben) nach Gestenbedingung (IKON, AUFM) zu zwei Postmesszeitpunkten

Im o.a. zusätzlichen Experiment mit 18 vierjährigen TD Kindern wurden anstatt der konstanten aufmerksamkeitslenkenden Geste als Kontrollbedingung itemspezifische, dynamische arbiträre Gesten verwendet. Die Kinder benannten beim zweiten Postmesszeitpunkt die mit ikonischen Gesten erlernten Zielwörter besser als die mit arbiträren Gesten erlernten; der deskriptive Vorteil wurde jedoch nicht signifikant.

Beim zweiten Postmesszeitpunkt wurde Kindern, denen das korrekte Benennen nicht gelang, die jeweilige Geste, mit der sie die Zielitems erlernt hatten, als Hinweisreiz (Cue) zum Wortabruf präsentiert. Sowohl die Kinder mit USES wie auch beide TD Gruppen benannten die Zielitems mit der zusätzlichen Präsentation ikonischer Gesten besser als

ohne Hinweisreiz. Nur bei den Kindern mit USES, aber nicht bei den TD Kindern, führte das Präsentieren der aufmerksamkeitslenkenden Geste als Hinweisreiz zu einer marginal besseren Benennleistung als ohne Hinweisreiz (Abb. 3).

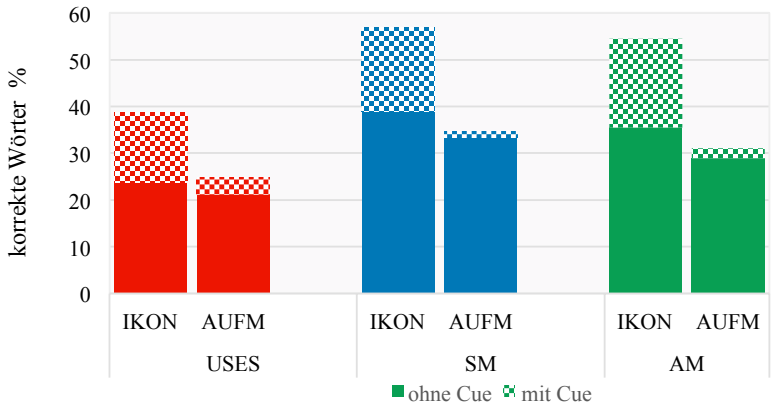

Abb. 3. Anteil korrekt benannter Zielitems (Mittelwerte) ohne Hinweisreiz (einfarbige Füllung) und mit Hinweisreiz (gemusterte Füllung) nach Gestenbedingung (IKON, AUFM) je Gruppe (USES, SM, AM) zum zweiten Postmesszeitpunkt

Wörter definieren: Anzahl definierter Wörter

Die jüngeren TD Kinder definierten tendenziell weniger Zielitems als die Kinder mit USES. Bei acht jüngeren TD Kindern zeigten sich Bodeneffekte, bei den Kindern mit USES war dies bei drei Kindern, bei den älteren TD Kindern bei einem Kind der Fall. Die Kinder aller drei Gruppen definierten mehr mit ikonischen Gesten erlernte Zielitems als mit aufmerksamkeitslenkenden Gesten erlernte, sowohl Nomen wie Verben. Die Anzahl der von den Kindern definierten Nomen und Verben unterschied sich nicht. (Wenn allerdings in der Auswertung bei Verben das Ausagieren der jeweiligen Bewegung nicht berücksichtigt wurde, dann wurden von allen Gruppen mehr Nomen als Verben definiert).

Qualitative Aspekte: Tiefe des Wortwissens

Wörter definieren: Anzahl von Bedeutungsinformationen pro Zielwort

Die Kinder mit USES gaben pro Zielitem mehr Informationen über deren Bedeutung als die jüngeren TD Kinder. Die Tiefe des Bedeutungswissens wurde durch die Gestenbedingung bei den Kindern mit USES mehr beeinflusst als bei den TD Kindern. Kinder mit USES gaben mehr Informationen über die Bedeutung von mit ikonischen Gesten erlernten Zielwörtern als über die Bedeutung von mit aufmerksamkeitslenkenden Gesten erlernten Wörtern. Bei den TD Kindern (beider Gruppen) war das nicht der Fall; sie gaben Bedeutungsinformationen über die Zielitems unabhängig von der Gestenbedingung

(Abb. 4). Nomen und Verben unterschieden sich (bei Berücksichtigung nonverbaler Reaktionen bei Verben) hinsichtlich der über sie gegebenen Menge an Bedeutungsinformationen nicht.

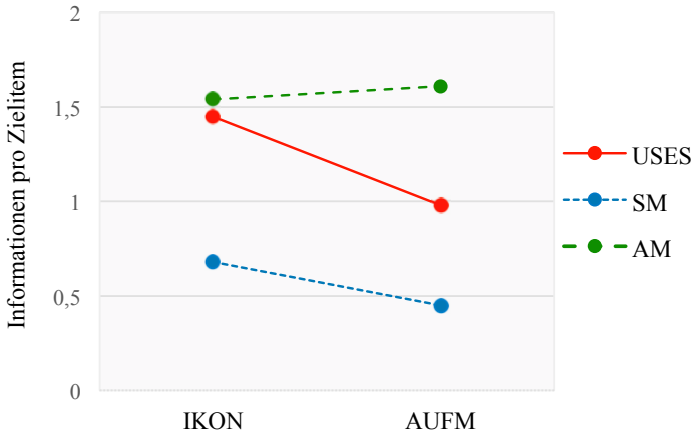

Abb. 4. Bedeutungsinformationen pro Zielitem (Mittelwerte) nach Gestenbedingung (IKON, AUFM) je Gruppe (USES, SM, AM) zum zweiten Postmesszeitpunkt

Diskussion

Die Studie untersuchte den Einfluss ikonischer versus aufmerksamkeitslenkender Gesten auf das Erlernen von Nomen und Verben bei Vorschulkindern mit USES und einer nach Alter sowie einer nach Sprachfähigkeiten parallelisierten jüngeren TD Kontrollgruppe. Die Ergebnisse werden im Folgenden zusammengefasst und diskutiert.

Wortlernen bei Kindern mit und ohne USES

Das durchgeführte Wortlerntraining umfasste aufgrund der unterschiedlichen linguistischen Voraussetzungen in den Probandengruppen zwölf Zielitems bei den älteren TD Kindern, aber nur acht bei den Kindern mit USES und den jüngeren TD Kindern. Erwartungsgemäß gelang so das Erlernen neuer Wörter in allen drei Gruppen: es zeigte sich ein stetiger Lernzuwachs beim Verstehen und Benennen der Wörter. Da die Anforderung an die ältere TD Gruppe höher war, ist ein Gruppenvergleich der Gesamtwerte nur eingeschränkt möglich.

Die Forschungsliteratur zeigt mehrheitlich, dass sowohl beim lexikalischen als auch beim semantischen Lernen Kinder mit USES schlechtere Wortlernfähigkeiten als altersgleiche TD Kinder zeigen, aber vergleichbare mit jüngeren, sprachlich parallelisierten TD Kindern (Kan, 2010; Nation 2014). Da in dieser Studie die jüngeren TD Kinder zu den USES Kindern hinsichtlich ihrer Wortschatzfähigkeiten parallelisiert waren, waren ähnliche Leistungen bei den Outcomemaßen erwartbar. Diese Erwartung erfüllte sich jedoch nicht. Beim Verstehen und Benennen der Zielitems unterschieden sich die Leistungen der Kinder mit USES zum ersten Postmesszeitpunkt nicht von denen der jüngeren TD Kinder. Beim zweiten Postmesszeitpunkt aber schnitt die USES Gruppe beim Verstehen und beim Benennen schlechter ab. Somit gelang es den Kindern mit USES zwar, eine erste, vorläufige Verbindung zwischen einer lexikalischen Form und deren Bedeutung aufzubauen; diese Verbindung stabil zu speichern fiel ihnen aber schwer. Diese Studienergebnisse bestätigen Forschungsbefunde, dass für sprachauffällige Kinder weniger der erste Abbildungsprozess im Sinne des fast mapping, sondern die Qualität und das Tempo der Verankerung neuer Einträge im Lexikon das vorherrschende Problem sind (Kan & Windsor, 2010; Nation, 2014; Rothweiler, 2001).

Andererseits waren in dieser Studie die Kinder mit USES im Erwerb von Wortbedeutungen überlegen, denn sie definierten tendenziell mehr Zielitems und äußerten mehr Wissen über die Bedeutung der Zielwörter als die jüngeren TD Kinder. Die Ergebnisse deuten darauf hin, dass Kinder mit USES ein tieferes Durchdringen der

Wortbedeutung erlangen können und das semantische Lernen im Vergleich zu sprachlich parallelisierten Kindern eine relative Stärke sein kann. Da dieses Ergebnis von früheren Befunden abweicht (z.B. Laws, Briscoe, Ang, Brown, Hermena & Kapikian, 2015; Nash & Donaldson, 2005), muss es im Kontext der in dieser Studie verwendeten sprachbegleitenden Gesten diskutiert werden (s.u.). Zweifellos ist das Resultat aber ermutigend für die Intervention, zeigt es doch, dass auch Kinder mit USES effektiv die Bedeutung neuer Wörter erwerben können, wenn die Lernanforderungen ihren (linguistischen) Fähigkeiten angepasst werden.

Ferner scheint es beim Wortlernen qualitative Unterschiede zwischen den USES und TD Gruppen zu geben, denn trotz relativ besserem Bedeutungswissen waren die Kinder mit USES beim Wortverstehen und Benennen im Nachteil gegenüber jüngeren TD Kindern, während diese auch mit relativ weniger Bedeutungswissen den Link zur lexikalischen Form speichern und aktivieren konnten. Die lexikalischen Fähigkeiten im Sinne von Verstehen und Benennen scheinen also nicht ausschließlich von der Menge an Bedeutungswissen abzuhängen. In eine ähnliche Richtung weisen Befunde von Funnel, Hughes und Woodcock (2006) bei TD Kindern, die zeigen, dass das Alter der Kinder einen Einfluss auf den Zusammenhang von Benennleistung und Bedeutungswissen nimmt: Während bei jüngeren TD Kindern die Fähigkeit, Objekte zu benennen, die Fähigkeit, diese Objekte zu definieren, übertraf, überwogen umgekehrt bei älteren TD Kindern die Definitionsfähigkeiten. Jüngere Kinder nutzten ähnlich wie in dieser Studie sehr effektiv die Verbindung Form-Bedeutung und zeigten eine vergleichsweise hohe Benennfähigkeit. Diese Fähigkeit scheint mit zunehmendem Alter zugunsten eines relativen Anstiegs von Bedeutungswissen abzunehmen. Da die Kinder mit USES in dieser Studie durchschnittlich 1;3 Jahre älter als die sprachparallelisierten TD Kinder waren, könnte der von Funnel et al. (2006) berichtete Effekt eventuell eine Rolle spielen.

Der Einfluss ikonischer Gesten auf das Wortlernen

Überlegenheit ikonischer Gesten über andere Gestenarten

Der Fokus der Studie lag auf dem Einfluss ikonischer Gesten auf das Erlernen von Nomen und Verben im Vergleich zu Gesten, die die Aufmerksamkeit auf die neuen Wörter lenken. Die Ergebnisse zeigen insgesamt einen Vorteil der ikonischen Gesten.

Die Kinder aller drei Gruppen verstanden und benannten zu beiden Postmesszeitpunkten mehr mit ikonischen Gesten als mit aufmerksamkeitslenkenden Gesten präsentierte Wörter. Die Präsentation ikonischer Gesten verbesserte somit das fast mapping, also die

vorläufige Zuordnung einer lexikalischen Form zu einer Bedeutung, und die längerfristige Speicherung (slow mapping). Dieses Ergebnis stützt vorherige Befunde, dass ikonische Gesten zusätzlich zum rein verbalen Input das Wortlernen von Kindern mit USES verbessern (Ellis Weismer & Hesketh, 1993; Lüke & Ritterfeld, 2014). Außerdem können frühere Forschungsergebnisse zur Überlegenheit ikonischer Gesten gegenüber Zeigegesten bei TD Kindern (Capone Singleton, 2012) bestätigt und außerdem auf Kinder mit USES erweitert werden. Auch für den Erwerb von Bedeutungswissen zeigt sich ein Vorteil ikonischer gegenüber aufmerksamkeitslenkenden Gesten, denn alle Gruppen definierten mehr mit ikonischen Gesten präsentierte Zielwörter. Woher kommt diese Überlegenheit? In Tabelle 2 werden die Merkmale verschiedener Gestenarten in Bezug auf das Wortlernen dargestellt.

Tab. 2: Merkmale verschiedener Gestenarten in Bezug auf das Wortlernen

Merkmale	Visueller Reiz zusätzlich zum verbalen Input vorhanden	Geste lenkt Aufmerksam-keit auf den Referenten	Geste lenkt Aufmerksam-keit auf den verbalen Input	Geste repräsentiert den Referenten	Geste greift Bedeutungs-merkmal des Referenten auf
Keine Geste	-	-	-	-	-
Zeigegesten	+	+	-	-	-
Aufmerksam-keitslenkende Gesten	+	-	+	-	-
Arbiträre Gesten	+	-	+	+	-
Ikonische Gesten	+	-	+	+	+

Ähnlich wie aufmerksamkeitslenkende und Zeigegesten fokussieren ikonische Gesten die Aufmerksamkeit und erhöhen die Salienz für die Zielwörter. Dies erleichtert die Speicherung und Verankerung der Verbindung von lexikalischer Form und Bedeutung. Darüber hinaus aber fungieren ikonische Gesten als Symbole, d.h. sie repräsentieren die

Referenten. Dies scheint das Wortlernen zusätzlich zu unterstützen. Die symbolische bzw. repräsentative Funktion ikonischer Gesten wird auch durch die weiteren Ergebnisse der Aufgabe `Benennen´ deutlich. Wenn die Kinder beim zweiten Messzeitpunkt die Zielwörter nicht benennen konnten, wurde ihnen die Geste gezeigt, die im Training immer mit dem Zielwort präsentiert worden war. Dieser Hinweisreiz (Cue) wurde von den Kindern genutzt und führte zu einer Verbesserung der Benennleistung. Bei aufmerksamkeitslenkenden Gesten war das nicht der Fall. Die Kinder nutzten also die ikonischen Gesten in ihrer Symbolfunktion, um die Verbindung zur lexikalischen Form zu aktivieren.

Da auch arbiträre Gesten solch eine symbolische bzw. repräsentative Funktion erfüllen, allerdings ohne visuelle Ähnlichkeit zum Referenten, wurde diese Gestenart mit ikonischen Gesten in einem zusätzlichen Experiment mit TD Kindern verglichen. Die Ergebnisse deuten darauf hin, dass der Vorteil ikonischer Gesten vermutlich auch gegenüber arbiträren Gesten bestehen bleibt und dass die Kinder die charakteristische Eigenschaft ikonischer Gesten, (nämlich die Abbildung von Bedeutungsmerkmalen des Referenten) als Zusatzinformation gewinnbringend verarbeiten, um neue Lexikoneinträge aufzubauen und diese stabil zu speichern. Es bedarf allerdings weiterer Forschung zur Untermauerung der Befunde.

Einfluss ikonischer Gestenformen auf den Erwerb von Nomen und Verben

Darüber hinaus zeigen die Ergebnisse, dass die Kinder sowohl von den ikonischen Formgesten für den Erwerb von Objektbezeichnungen als auch von ikonischen Gesten der Art und/oder Richtung für das Erlernen von Bewegungsverben profitierten, dies aber zu unterschiedlichen Erwerbsphasen. Ikonische Gesten der Art/Richtung für Bewegungen wirkten unmittelbar und begünstigten das fast mapping. Demgegenüber übten ikonische Formgesten ihren Einfluss eher längerfristig aus und unterstützen das slow mapping von Nomen. Dieses Ergebnis passt zu den Ergebnissen der Studie von Lüke & Ritterfeld (2014), in der die Kinder von ikonischen Formgesten nicht für das fast mapping, sondern erst für das slow mapping profitierten. Ikonische Gesten für Handlungen scheinen ihre Wirkung demnach anders zu entfalten als ikonische Formgesten. Während ikonische Formgesten ein einzelnes Merkmal des Referenten (in diesem Fall die Form eines Objekts) aufgreifen und so den Referenten repräsentieren, verkörpern ikonische Gesten der Art/Richtung die Handlung an sich und werden so vermutlich eher mit dem Referenten in

Deckung gebracht. Sie scheinen dadurch kognitiv zugänglicher zu sein (Hodges et al., 2015; Novack et al., 2015).

Wirksamkeit ikonischer Gesten auf das Wortlernen von Kindern mit und ohne USES

Die oben beschriebene Überlegenheit ikonischer Gesten traf auf alle drei Gruppen gleichermaßen zu: Die Kinder verstanden, benannten und definierten in den Nachuntersuchungen mehr Wörter, die im Training mit ikonischen Gesten präsentiert worden waren. Damit reagierten Kinder mit USES und TD Kinder identisch auf die Gestenbedingung und verbesserten mithilfe von ikonischen Gesten die Breite ihres Wortwissens besser als mithilfe von aufmerksamkeitslenkenden Gesten.

Bezogen auf die Tiefe des Bedeutungswissens, d.h. wie gut die Kinder die Zielwörter kannten und definierten, stellt sich dies jedoch anders dar. Nur die Kinder mit USES, nicht aber die TD Kinder, hatten ein tieferes Bedeutungswissen und nannten mehr Informationen über die mit ikonischen Gesten präsentierten Zielwörter. Offenbar nutzten (jüngere und altersgleiche) TD Kinder die Informationen ikonischer Gesten vorwiegend für den Aufbau und die Speicherung der Verbindung von lexikalischer Form und Bedeutung und erwarben tiefgehendes Wissen über die Wortbedeutung unabhängig von der Gestenbedingung. Die Kinder mit USES hingegen verwerteten die Informationen ikonischer Gesten außerdem auch für den Erwerb von Wortbedeutungswissen und profitierten damit mehr von den zusätzlichen visuellen Informationen, die die ikonischen Gesten ihnen boten.

Die Ergebnisse weisen in eine ähnliche Richtung wie frühere Forschungsarbeiten, die engere Beziehungen zwischen Sprache und Gesten bei Kindern mit USES im Vergleich zu TD Kindern beschrieben (Botting et al., 2010; Lavelli, Barachetti & Florit, 2015). Ikonische Gesten vermittelten relevante Informationen, die von sprachauffälligen und TD Kindern verarbeitet und für den Aufbau und die Speicherung von Lexikoneinträgen und von Bedeutungswissen genutzt wurden. Ganz besonders aber schöpften Kinder mit USES die Gesten als kommunikatives Inventar aus. Der in der Literatur beschriebene größere Gestenvorteil bei Kindern mit USES findet durch diese Studie Unterstützung.

Da die beschriebenen Befunde sich auf Gruppenmittelwerte beziehen, bleibt offen, welche Kinder individuell von ikonischen Gesten profitieren. Ellis Weismer & Hesketh (1993) hatten aufgrund der Resultate einer fast mapping Studie gemutmaßt, dass ikonische Gesten insbesondere USES Kinder mit rezeptiven Einschränkungen unterstützen könnten. In der vorliegenden Studie gibt es dafür keine eindeutige Evidenz. Hier besteht weiterer Forschungsbedarf.

Wortarten

Ein weiteres interessantes Ergebnis der Studie ist, dass sich kaum Unterschiede zwischen dem Erwerb von Nomen (für Objekte) und Verben (für Bewegungen) ergaben. Die Kinder bauten bei beiden Wortarten in ähnlichem Ausmaß die initiale Verbindung zwischen der lexikalischen Form und deren Bedeutung auf, speicherten diese und erwarben Bedeutungsinformationen über die Objekte und Handlungen.

In der Literatur wird der Erwerb von Verben bei TD Kindern als schwieriger als der von Nomen beschrieben, bei Kindern mit USES ist der Effekt sogar noch stärker ausgeprägt (Alt, Plante & Creusere, 2004; Kan & Windsor, 2010). In dieser Studie liegt solch ein Nomen bias nicht vor. Möglicher Weise liegt die Diskrepanz der Befunde an der Verwendung ganz bestimmter, nicht als repräsentativ anzusehender Zielitems, nämlich Nomen für rare Tierarten und Verben für anschauliche Bewegungsarten, die im Training auch ausagiert wurden. Außerdem wurden bei der Auswertung der Aufgabe `Wörter definieren´ auch nonverbale Reaktionen hinsichtlich der Bedeutung von Verben berücksichtigt. Die Ergebnisse legen nahe, künftig das nonverbale Verhalten der Kinder stärker in den Blick zu nehmen.

Klinische Implikationen

Aus der vorliegenden Arbeit ergeben sich Implikationen für die sprachtherapeutische Praxis. Die Ergebnisse zeigen, dass auch Kinder mit USES, die bekanntermaßen häufig Schwierigkeiten beim Wortlernen aufweisen, effektiv neue Wörter und deren Bedeutung erwerben können, wenn ihnen ein reichhaltiger, hochfrequenter, wiederholter und strukturierter Input zu einer überschaubaren Anzahl an neuen Wörtern in vielfältigen Kontexten vorzugsweise im Einzel- oder Kleingruppensetting angeboten wird.

Ikonische Gesten haben mehr als andere Gestenarten das Potenzial, das Wortlernen positiv zu unterstützen. Von diesem positiven Effekt können neben Kindern in Förderkontexten ganz besonders Kinder mit USES in der Sprachtherapie profitieren. Das Anbieten ikonischer Gesten parallel zum gesprochenen Zielwort soll dabei nicht verbale Methoden (wie z.B. Modellierungstechniken) ersetzen, sondern diese ergänzen. Geschichten, Gedichte und Lieder eignen sich hier sehr gut, denn sie lassen sich häufig wiederholen und außerdem in der Sprachtherapie wie im Kindergarten verwenden. In der Regel mögen Kinder Wiederholungen, und gerade Kinder mit schwächeren Sprachfähigkeiten können ganz besonders davon profitieren.

Die initiale Verbindung lexikalischer Formen mit einer Bedeutung kann für Verben besonders durch ikonische Gesten der Richtung und/oder der Art und Weise unterstützt werden. Demgegenüber eignen sich ikonische Formgesten besonders für die Konsolidierung von Nomen.

Es empfiehlt sich, die Gesten konsequent parallel zum gesprochenen Zielwort zu präsentieren, auch wenn das Kind möglicherweise nicht darauf reagiert (z.B. durch Imitation). In dieser Studie wurden die Gesten aus methodischen Gründen nicht explizit thematisiert und die Kinder wurden nicht zur Imitation ermuntert. Möglicher Weise würde sich das Imitieren der Gesten in der Praxis aber zusätzlich positiv auswirken. Studien zum Zweitspracherwerb bei Kindern (Tellier, 2008) und Erwachsenen (Macedonia & Knösche, 2011) und zum Erwerb von Pseudowörtern bei Erwachsenen mit Aphasie (Kroenke, Kraft, Regenbrecht & Obrig, 2013) deuten auf solch einen `enactment´ Effekt (Engelkamp & Cohen, 1991) hin.

Schließlich stellten sich ikonische Gesten als wirkungsvolle Hilfe für den Wortabruf heraus. Selbst aufmerksamkeitslenkende Gesten, denen keinerlei semantische Informationen inhärent sind, verhalfen manchen Kindern mit USES zu erfolgreichem Wortabruf. Daher sollten in der Sprachtherapie Gesten systematisch als Abrufstrategie Einsatz finden.

Schlussfolgerungen und Ausblick

Die vorliegende Arbeit untersuchte den relativen Einfluss sprachbegleitender ikonischer Gesten auf das Wortlernen an einer für eine Generalisierung hinreichend großen Stichprobe von Kindern mit einer USES und jeweils einer hinsichtlich Alter bzw. Sprachfähigkeiten vergleichbaren Gruppe typisch entwickelter Kinder. Dabei wurde das Wortlernen als Prozess über einen Zeitraum erfasst und quantitative wie qualitative Aspekte des Wortwissens überprüft.

Die Ergebnisse zeigen durchweg einen positiven Einfluss ikonischer Gesten auf das Wortlernen. Ikonische Gesten erleichtern den Aufbau der Verbindung einer lexikalischen Form mit einer Bedeutung und deren längerfristige Speicherung bei Kindern mit USES und TD Kindern, und sie tun dies besser als andere Gestenarten. Überdies haben ikonische Gesten das Potenzial, als Abrufhilfe das Benennen neu erlernter Wörter zu unterstützen. Mehr noch als typisch entwickelte Kinder nutzen Kinder mit USES die spezifische Eigenschaft ikonischer Gesten, Merkmale eines Referenten visuell abzubilden, um deren Bedeutung zu durchdringen und (tiefes) Wortbedeutungswissen aufzubauen.

Die im Rahmen dieser Dissertation gewonnen Ergebnisse ergänzen und erweitern vorhandene Wissensbestände darüber, wie sprachbegleitende ikonische Gesten das Wortlernen von sprachauffälligen und typisch entwickelten Kindern beeinflussen und begünstigen. Sie tragen dazu bei, ein differenzierteres Bild über die Rolle von Gesten und speziell von ikonischen Gesten zu gewinnen und die Wirkweise spezifischer ikonischer Gesten besser zu verstehen. Zukünftige Forschung sollte diese Ziele weiterverfolgen und ihre Ergebnisse in einem Modell zur Verarbeitung ikonischer Gesten zusammenfassen. Die oben angestellten Überlegungen könnten bei der Entwicklung solch eines Modells einfließen.

Offen und damit als Aufgabe für nachfolgende Studien bleibt, welche Kinder individuell von ikonischen Gesten profitieren und welche eher weniger. In dieser Studie ergaben sich hinsichtlich dieser Frage keine klaren Muster. Aufschlussreich wäre weiterhin zu untersuchen, ob sich die berichteten Ergebnisse verändern, wenn die Kinder die Gesten nicht nur beobachten, sondern auch imitieren, und ob sich dies möglicher Weise zusätzlich positiv auf das Wortlernen auswirkt.

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Observing iconic gestures enhances word learning in typically developing children and children with specific language impairment*

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ABSTRACT

Research has shown that observing iconic gestures helps typically developing children (TD) and children with specific language impairment (SLI) learn new words. So far, studies mostly compared word learning with and without gestures. The present study investigated word learning under two gesture conditions in children with and without language impairment. Twenty children with SLI (age four), twenty age-matched TD children, and twenty language-matched TD children were taught words that were presented with either iconic or non-iconic gestures. Results showed that children of all groups benefited more successfully from observing iconic gestures for word learning. The iconic gesture advantage was similar across groups. Thus, observing iconic gestures prompts richer encoding and makes word learning more efficient in TD and language impaired children.

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INTRODUCTION

Human communication is multimodal, including gestures. Gestures are visible actions of body parts (Kendon, 2004) and constitute a crucial part of conversation. Co-speech gestures accompany spoken speech. They contribute to felicitous communication by facilitating listeners' comprehension of a spoken message (Beattie & Shovelton, 2006; Hostetter, 2011; Kendon, 1994) and help speakers retrieve information stored in the mental lexicon (Frick-Horbury & Guttentag, 1998; Krauss, Chen & Gottesman, 2000; Ruiter, 2000). The close relationship between gesture and speech and their mutual influence are widely recognized. Accounts of embodied cognition assume that motor actions, such as observing a speaker gesturing, enhance memory and learning (Madan & Singhal, 2012).

Gestures are classified into different types. Here, we focus on iconic hand gestures, which capture meaning aspects of the entity that is conveyed by the gesture (McNeill, 1992), for example flapping hands representing a bird flying. Iconic gestures have been suggested to facilitate word learning. It is argued that iconic gestures are less arbitrary than most spoken symbols. The visuospatial aspects of gesture help process the accompanying speech and lead to strengthened memory traces and deeper conceptual understanding (Hostetter, 2011; So, Chen-Hui & Wei-Shan, 2012). A comprehensive review of the existing literature (Hostetter, 2011) proposed that gestures are particularly helpful to children. The focus of the present study is on word learning in typically developing (TD) children and in children with specific language impairment (SLI). Previous research indicated a gesture advantage in children with SLI as compared to their TD peers such that they show stronger associations between gesture and language (Botting, Riches, Gaynor & Morgan, 2010), and benefit more from gesture input for pragmatic comprehension (Kirk, Pine & Ryder, 2011; Lavelli, Barachetti & Florit, 2015). So far, this has not been demonstrated for word learning. Therefore, it is interesting to investigate the influence of gestures on word learning in typically developing and language impaired populations.

Word learning in children with SLI

SLI is defined as a developmental language disorder in the absence of any identifiable reason for the disorder (Bishop, 2014; Leonard, 1998). It is generally agreed that the population is heterogeneous and that children with SLI show various deficits in language, including slow acquisition of the lexicon and grammar, and limited comprehension and production of vocabulary or grammatical forms (Bishop & Snowling, 2004; Conti-Ramsden & Botting, 2004; Leonard, 2009). Limited processing capacities and difficulty with sustained attention are reported as well (Alt,

Myers & Alt, 2013; Ebert & Kohnert, 2011; Eichorn, Marton, Campanelli & Scheuer, 2014; McKean, Letts & Howard, 2013; Sheng & McGregor, 2010).

Problems with word learning are often part of the characteristics associated with SLI. Word learning is a process in which word representations are gradually established, starting from an incomplete representation after first perceiving the new form–referent link through fast mapping until the word is represented and stored completely through slow mapping (Horst & Samuelson, 2008; Justice, Meier & Walpole, 2005). Children with SLI are reported to have weak word knowledge, i.e. weak semantic and phonological representations, compared to peers. Thereby, both fast and slow mapping are affected (Alt *et al.*, 2013; Gray, 2003; McKean *et al.*, 2013). Given that the vocabulary deficiencies seem to reflect immaturities in semantic representation (McGregor, Newman, Reilly & Capone, 2002; Sheng & McGregor, 2010), methods to support word learning in children with SLI are desirable. Below, we summarize findings regarding the role of iconic gesture as a means of enhancing word learning in TD children and children with SLI.

Contribution of observing iconic gesture to children's word learning

For word learning, children use a number of cues, gestures among them. To derive benefit from iconic gestures, two mechanisms are important. First, the child has to be capable of detecting the meaning conveyed by the gesture. While still fragile in toddlerhood, the ability to derive meaning from iconic gestures develops at three years of age and is acquired by age 3;5 to 4;0 (Namy, Campbell & Tomasello, 2004; Novack, Goldin-Meadow & Woodward, 2015; Stanfield, Williamson & Özçalışkan, 2014; Tolar, Lederberg, Gokhale & Tomasello, 2008). Preschool children can also learn from arbitrary gestures, but once they are able to recognize iconicity they learn from iconic gestures more readily than from arbitrary ones (Marentette & Nicoladis 2011; Namy *et al.*, 2004). Besides, some types of iconic gestures appear to be easier to identify than others, for example gestures depicting actions associated with an object (Hodges, Özçalışkan & Williamson, 2015), and gestures showing how an object is handled are recognized earlier in development than gestures based on the shape of an object (Tolar *et al.*, 2008). Second, the child has to be able to process and integrate multimodal information. While typical word learning implies mapping a spoken word onto a referent, word learning paired with gestures requires additional cognitive demands such that both a spoken word and a gesture have to be mapped onto the referent (Puccini & Liszkowski, 2012). It has been shown that children at age three are able to integrate information presented in iconic gesture and speech (Sekine, Sowden & Kita, 2015).

Evidence supporting the notion that observing iconic gestures facilitates word learning for a range of word classes comes from studies with young TD children. It has been demonstrated that seeing iconic gestures helped preschool children to focus on a particular aspect of novel verbs and thereby enhanced learning their meaning (Goodrich & Hudson Kam, 2009; Mumford & Kita 2014). Capone and McGregor (2005) showed that co-speech iconic gestures exemplifying the shape and function of novel objects improved word retrieval in toddlers. Moreover, iconic shape gestures were more effective than pointing gestures (Capone Singleton, 2012). McGregor, Rohlfing, Bean, and Marschner (2009) taught two-year-olds the preposition *under* either with or without iconic gestures. At delayed post-test, children showed a more robust and abstract knowledge of the meaning when the words were paired with a gesture. Moreover, it was found that observing iconic gestures was particularly effective when spoken messages were complex (McNeil, Alibali & Evans, 2000). Observing iconic gestures appears to improve immediate comprehension and, in particular, benefit slow mapping (McGregor *et al.*, 2009; Munro, Baker, McGregor, Docking & Arciuli, 2011). Two studies suggest that iconic co-speech gestures can serve to scaffold word learning in children with SLI. Work by Ellis Weismer and Hesketh (1993) has shown that in a fast mapping task children with SLI as well as TD children understood novel spatial terms better when the words were trained with iconic gestures compared to words trained without additional input. However, there were no effects on naming. Lüke and Ritterfeld (2014) expanded this work by additionally investigating slow mapping. Effects of observing iconic shape gestures on the learning of names for cartoon characters were compared to a no-gesture condition. Contrary to Ellis Weismer and Hesketh's (1993) study, no immediate advantage of the iconic gesture condition emerged. However, during slow mapping children showed a gesture benefit for naming – but not for comprehension. The authors of both studies conclude that observing iconic gestures leads to more efficient word learning in children with SLI. Yet, generalization of this conclusion has serious limitations. First, stimuli used in the studies (novel words for spatial terms, whose meaning children already knew, and proper names for cartoon characters) are not representative of the words children acquire. Second, the number of children with SLI in the experimental groups was rather small (eight and ten children, respectively).

Moreover, in both studies the control condition was merely an absence of gesture, involving no additional cues beyond speech. Hence, word learning conditions differed with respect to their processing demands (So *et al.*, 2012; Yap, So, Yap & Tan, 2011): Whilst in the iconic learning condition both a spoken word and a gesture had to be mapped onto the referent, the control condition required the child to process auditory information only

(Puccini & Liszkowski, 2012). In a 'gesture vs. no-gesture' design, it remains unclear whether children benefit from iconic gestures due to the specific information conveyed by the gesture, or rather because the additional visual input directed children's attention to the target words and thus improved learning. In order to show that iconic gestures do more than focus attention, demonstration of an iconic gesture benefit over a control condition that goes beyond a no-gesture condition is required. However, studies comparing two different gesture types in word learning (in terms of mapping a lexical form and semantics) are rare. Lüke and Ritterfeld (2014) conducted a fast mapping experiment and found that both iconic and arbitrary gestures had a beneficial effect on TD preschoolers' initial word learning. Capone Singleton (2012) demonstrated enhanced learning of novel nouns paired with iconic gestures as compared to pointing gestures. Pointing gestures are stationary gestures which scaffold referential understanding by focusing children's attention on the referent whose lexical form they are learning (Novack *et al.*, 2015), provided the referent is in the immediate environment. Iconic gestures, however, require attention to hand movement and represent referents (Puccini & Liszkowski, 2012). Results led Capone Singleton (2012) to suggest that iconic gestures enrich semantic learning, establish more robust word knowledge, and in this way make word learning more efficient than pointing gestures do. The current study set out to substantiate and expand these findings.

Current study

For this purpose, we designed a study to compare the learning of unknown words (nouns and verbs) in a within-subjects design under two gesture conditions. In the experimental condition, new words were taught with iconic gestures. To ensure that a potential iconic gesture advantage does not merely reflect enhanced attention to the target word, we applied a control condition, in which the target words were paired with an attention-directing gesture in the form of a raised forefinger in front of the upper body. Such a gesture does not convey the semantic meaning of the referents, and resembles pointing gestures in that it is stationary and visually guides attention. At the same time, the control gesture covers functions of iconic gestures, such that it directs attention to hand movement, nevertheless lacking the specific property of iconic gestures, namely visually capturing meaning aspects of the referent. Rather, the control gesture guides listeners to attend to particular parts of the utterance, increases the salience of the word, and thus serves a metalinguistic purpose. Such a control condition enabled us to investigate whether iconic gestures do more than focus attention. This approach

allowed us to compare two conditions where both the spoken word and a gesture have to be mapped onto the referent. In a subsequent control experiment, we modified the control condition by using different arbitrary gestures instead of the constant attention-directing gesture.

We investigated the ability to learn words in two gesture conditions in TD children and children with SLI, and assumed that children of either group could master the task. Our main research interest was on the relative effect of observing co-speech iconic gestures on word learning. The following hypotheses were tested:

1. Observing iconic co-speech gestures should impact more effectively on word learning than observing non-iconic gestures. This hypothesis grounds on research showing that children by the age of three can master the cognitive requirements to process co-speech gesture and can learn from iconic gestures. Moreover, enhanced learning with iconic gestures as compared to pointing gestures was demonstrated in young TD children (Capone Singleton, 2012). We expected that this effect would apply to the learning of both nouns and verbs, since an iconic advantage over mere verbal input has been found for a range of word classes, including nouns and verbs. Finally, former research gives rise to the hypothesis that such an iconic effect should be apparent at both the initial learning and the retention of the new words.
2. It was expected that observing iconic gestures would have a positive influence on word learning in children with and without language impairment. However, as children with SLI are a special group of language learners it is unclear whether the degree of the iconic gesture advantage differs across groups.

METHOD

A word learning study was conducted employing a mixed design to test for differences between two learning conditions, involving three groups of preschool children: (i) twenty children with SLI; (ii) twenty TD children matched individually for chronological age (±9 months) and gender (age-matched group, AM); and (iii) twenty TD children matched individually to children with SLI for grammar comprehension and word comprehension scores (±½ SD) (language-matched group, LM). Observations extended over three points in time. The University of Applied Sciences Fresenius Ethics Committee gave approval for the study.

Participants

Participants in the study were TD children and children with SLI from the wider areas of Frankfurt and Hamburg in Germany. TD children were

recruited via nurseries, children with SLI via certified speech–language therapists. All children were drawn from middle-class backgrounds regarding parental education and professional training as indicated by parent reports. The parents gave informed consent to the study and answered a questionnaire focusing on the child's general and language development. Criteria for inclusion were: (i) age under six; (ii) normal general development, including physical, sensory, and non-verbal cognitive skills according to parent reports; and (iii) monolingual German speakers.

Children with SLI had formerly been diagnosed by the child's speech and language therapist. Detailed information regarding language skills and intervention was obtained through a therapist-reported questionnaire. Importantly, no treatment involved gestures. The diagnoses and information concerning language and non-verbal cognitive skills were confirmed by standardized measures administered before training. Non-verbal cognitive ability was measured using the Coloured Progressive Matrices (CPM; Raven, Bulheller & Häcker, 2010) in SLI and AM children. Since this test does not provide normative data for children under age 3;9, non-verbal cognitive ability in LM children was measured using the subtest 'Muster legen' (patterns identification) of the Wiener Entwicklungstest (WET; Kastner-Koller & Deimann, 2012).

Language ability was measured using validated norm-referenced tests frequently used in clinical practice in Germany. The skills assessed were as follows: (i) grammar comprehension using the test for reception of grammar – German version (TROG-D; Fox, 2006); (ii) receptive and expressive vocabulary (nouns and verbs) using subtests of the Patholinguistische Diagnostik bei Sprachentwicklungsstörungen (PDSS; Kauschke & Siegmüller, 2010); (iii) word definition using a subtest of the WET (Kastner-Koller & Deimann, 2012); and (iv) nonword repetition using a subtest of the Sprachentwicklungstest für drei- bis fünfjährige Kinder (SETK3–5; Grimm, 2010). Additionally, speech sound disorders were assessed using the screening version of the Psycholinguistische Analyse kindlicher Sprechstörungen (PLAKSS; Fox, 2005). To examine scoring reliability, a second investigator scored 25% of the standardized assessments. Overall agreement was 96%.

In addition to parent report and therapist's diagnosis, to be included in the group with SLI the child had to perform more than one standard deviation (SD) below the mean on at least three of the language subtests administered. Controls had to perform within normal range in all language assessments. Five children with SLI and thirteen TD children who did not meet the criteria were excluded from the study.

The final sample consisted of twenty children with SLI (10 girls, 10 boys) with a mean age of 4;6 (SD 0;7), twenty children matched for age and gender (AM; mean age 4;5, SD 0;3), and twenty younger children matched for

language (LM; 11 girls, 9 boys; mean age 3;3, SD 0;16). Group means and standard deviations of the cognitive and language testing in terms of percentile ranks and raw scores as well as between-group comparisons for the children with SLI and the control groups are reported in Table 1.

All children fulfilled the requirement of lying within the normal range for non-verbal cognition. One-way analyses of variance (ANOVA) showed a significant group effect ($F(2,49) = 6{\cdot}67$, $p = {\cdot}003$, $\omega = {\cdot}18$). Post-hoc analyses (Bonferroni) revealed that AM children performed significantly better than LM children on the cognitive measure ($p = {\cdot}002$), an effect which we attribute to the use of different tests in AM and LM children. There was no significant difference between LM and SLI children ($p = {\cdot}307$). AM children did not differ from children with SLI with respect to non-verbal cognition ($p = {\cdot}163$). Note that we were not interested in whether AM children performed better in the training than children with SLI, but instead in how the different groups responded to the learning conditions.

Regarding language measures, mean scores for the children with SLI were significantly lower than the scores of the AM children on each of the measures, whereas they did not differ from those of the LM children. All children with SLI exhibited limited expressive language abilities, eleven children also showed receptive limitations. TD children exhibited overall normal-range performance.

General procedure

All assessments and training took part in a separate room in children's nurseries. Within two weeks, children were seen individually for six sessions lasting approximately 30 minutes each. All sessions were video recorded (JVC camcorder HD Everio GZ-V515). The procedure of the assessment and the training was explained to the children by the investigator in a child-appropriate way.

The first two sessions comprised assessment of non-verbal cognition and language measures (independent variables). Moreover, children's knowledge of the target words to be learned in the training (dependent variables: naming and comprehension task) was assessed (T0). Subsequently, three training sessions were conducted two to three days apart. The target words were introduced during the first session and repeated in the following two sessions. Learning achievement was assessed immediately after the first training (T1, fast mapping) and two to three days after completion of the training (T2, slow mapping) – as shown in Figure 1.

Target stimuli

The target items consisted of twelve German words (6 nouns and 6 verbs). Nouns represented rare animal species, verbs were intransitive and

TABLE 1. *Participant characteristics for the group with SLI and controls*

Independent variable	Scores	**AM** (n = 20) M (SD)	*t*	**SLI** (n = 20) M (SD)	*t*	**LM** (n = 20) M (SD)
Age in months		53·1 (3·5)		54·5 (7·4)		39·1 (1·6)
Non-verbal cognition	Percentile[a]	85·3 (18·3)	$p = .163$ n.s.	71·3 (25·3)	$p = .307$ n.s.	58·6 (20·7)
Grammar	Percentile	48·9 (29·7)	−4·24 ***	16·5 (16·6)		56·2 (25·4)
comprehension	Raw score	7·4 (3·1)		4·2 (2·1)	−0·56 n.s.	4·5 (1·8)
Noun comprehension	Percentile	52·5 (30·6)	−3·13 **	24·6 (25·4)		64·8 (28·7)
	Raw score	17·7 (1·3)		15·6 (2·1)	−0·73 n.s.	16·1 (2·1)
Verb comprehension	Percentile	61·3 (30·3)	−3·35 **	29·4 (29·8)		79·2 (20·8)
	Raw score	16 (2·2)		13·8 (3)	−0·28 n.s.	14·1 (2·5)
Noun naming	Percentile	58·8 (28·9)	−5·66 ***	16·7 (16·3)		74·2 (24·2)
	Raw score	16·2 (2·3)		10·6 (4)	−1·15 n.s.	11·8 (2·3)
Verb naming	Percentile	59·1 (41·1)	−5·65 ***	3·4 (11·5)		No normative data available
	Raw score	11·9 (3·7)		6·2 (3·3)	−0·85 n.s.	6·9 (2·1)
Word definition	Percentile	44·4 (24·2)	−3·93 ***	17·1 (15·7)		41·2 (15·6)
	Raw score	10·0 (2·4)		6·6 (3·2)	−1·12 n.s.	7·5 (1·6)
Nonword repetition	Percentile	64·9 (29·3)	−6·08 ***	15·2 (20)		42·7 (29)
	Raw score	10·6 (4·2)		4·06 (3·17)	−1·40 n.s.	5·5 (3)
Speech	Number of children with speech difficulty	5		18		2

NOTES: [a] Percentile: refers to a value on a scale of hundred (mean of 50 and standard deviation of 34) that indicates the percent of a distribution that is equal or below; M (SD) = mean (standard deviation); n = number of participants; ** $p < .01$, *** $p < .001$, n.s. = non-significant.

Fig. 1. Study design (training and assessments).

represented unusual movement types. When using real words in a training study, it is vital to ensure that children do not know the words prior to training. Thus, nouns and verbs of very low frequency were chosen from German dictionaries. Word frequency, if available, was determined by use of the corpus-based collection of the University of Leipzig (University of Leipzig, 1998–2013). In a pre-study, the words had been tested in TD four-year-old and five-year-old monolingual German children. None of the children (n = 16) had been able to name any of the stimuli. Assessment of comprehension – when presenting the target item and three distractors – showed a maximum of 7% to 21% of correct reactions to stimuli, which is below the chance level of 25%. Word forms were monosyllabic or bisyllabic, following the German trochaic prosodic pattern.

A pilot study revealed that children between four and five years of age were easily able to learn twelve words. For younger children and children with SLI, however, learning twelve words caused mental overload, reduced attention during training, and led to floor effects. For these children, learning eight new words turned out to be appropriate. In order to avoid ceiling or floor effects, we decided to train unequal numbers of target words (12 in AM, 8 in LM and children with SLI). Accordingly, data analyses are based on percentages.

Learning conditions

Children learned words under two conditions: in the iconic gesture condition (ICON), spoken stimuli were paired with a gesture that highlighted the shape of the animal (nouns) or the manner and/or path of the movement (verbs). Shape gestures had been shown to particularly support noun learning (Capone & McGregor, 2005) whereas manner gestures helped children interpret new verbs (Mumford & Kita, 2014). The gestures were dynamic iconic symbols lasting for 1–2 seconds, performed with the hands in the upper body or head region. A gesture-to-referent matching task was conducted with twenty-four adult students (age 19–24), confirming that adults were able to match the gestures to the respective referents in 83% to 98% on average. In the control condition, stimuli were paired with an

attention-directing gesture (ATTENT) in the form of a raised forefinger in front of the upper body. Stimuli and conditions are given in Table 2.

Half of the target words were learned in the ICON condition, the other half in the ATTENT condition. Words to be learned in the ICON and the ATTENT gesture condition were counterbalanced across children but remained paired with the referent throughout training.

Training procedure

All target words were introduced in the first training session and repeated in the next two sessions. Children were taught the words following a standard protocol, hearing the target words repeatedly being paired with either the ICON or ATTENT gesture. Children were allowed, but not encouraged, to imitate the gestures; however, their gesturing was not responded to. Throughout training, children were exposed to each target word twenty times before the first learning assessment (T1) and fifty-seven times before the second (T2). Since preschool children are familiar with listening to stories and benefit for word learning (Horst, Parsons & Bryan, 2011), a story was created and illustrated in a story book. The story comprised all target words and served as basis for the training. Training sessions were organized in three phases and specified in detail in a comprehensive training manual (see Table 3 for an overview of the content of sessions).

Learning assessment

We were interested in both the initial stage of word learning (fast mapping) and in the subsequent stage of gradual differentiation and retention of the word's meaning (slow mapping). Since our pilot study suggested that compliance and task performance deteriorated with repeated testing, we chose to assess learning performance immediately after the first training session (T1) and two to three days after training completion (T2). Learning achievement was assessed through naming and comprehension tasks.

a. *Assessment of naming performance:* a single coloured picture of the target in the middle of a page was shown to the child. The child was asked "What is this?" or "What is he doing?", respectively. Responses were classified as accurate if the child produced the target word or a morphological variant within a multiple-word response. Responses of children evidencing phonological difficulty were scored as correct if the phonological variation of the word had systematically been observed in the child's productions on the assessment measures.
b. *Assessment of comprehension performance:* the investigator presented the target word and the child had to point to one of four coloured pictures on a page (one target and three distractors). Two distractors depicted

TABLE 2. *Stimuli: words, pictures, and gestures in the iconic and attention-directing condition (Drawings copyright © 2013, Joy Katzmarzik leap4joy graphics)*

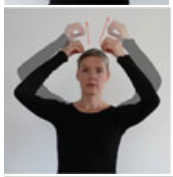
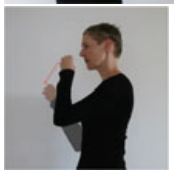
Nouns			Verbs		
		Iconic gesture			Iconic gesture
die Ralle 'the rail'			*staksen* 'to stalk'		
die Beisa 'beisa'			*retschen* 'to chute backwards'		
die Gopher 'gopher'			*hüpeln* 'to stand up on tiptoes'		
der Alk 'auk'			*krauchen* 'to creep'		

Table 2 (*cont.*)

Nouns		Iconic gesture	Verbs		Iconic gesture
der Fennek 'fennec'			*gliddern* 'to slide'		
der Numbat 'numbat'			*tippeln* 'to tippytoe'		
Attention-directing gesture					

TABLE 3. *Content and structure of each training session*

Activity	Time	Number of presentations of target items
Picture book reading: Investigator reads story live-voice to the child.	LM/SLI: 6 min (session 1 and 2) 5 Min. (session 3) AM: 7 min (session 1 and 2) 6 Min. (session 3)	9 (session 1 and 2) 6 (session 3)
Play: Investigator uses modelling procedures to specify semantic features of the referents (appearance, environment, food, and special attributes of animal species, location, realization, and distinctive features of the movement types). Examples: Noun *Beisa* 'beisa': "Here you see a *beisa*. The *beisa* loves to eat hay. We can feed the *beisa*. Hello *beisa*, are you hungry? Yes? So, let`s give the *beisa* some hay." Verb *staksen* 'to stalk': "Now we will *stalk*. To *stalk* we have to lift our legs. Look how I *stalk*. Can you also *stalk*? Hey, it's great how you *stalk*!"	LM/SLI: 7 min. AM: 9 min.	5
Watching a video: Child and investigator jointly watch a video clip in which an actor tells the story, thereby performing the respective gestures.	LM/SLI: 3 min. AM: 4:20 min.	6

an animal or movement that were taught during training, one distractor depicted an animal or movement not included in the training that was similar in shape and category to the target (e.g. target: rail, distractor: blackbird). To be counted as a correct comprehension response, the child had to point to the respective target.

Children earned one point for each correct response. For both naming and comprehension, self-corrections leading to the targets within 4 seconds were counted as accurate. Performance scores are expressed in percentages as unequal numbers of words were trained across groups. To evaluate scoring reliability, 25% of all dependent measures were scored via videotape by a second coder blind to the learning condition of responses. The mean point-to-point agreement was 95%.

Data analysis

Data were analyzed using omnibus 4-way mixed design ANOVAs with the independent variables (IV): test time (T0: pre-test, T1: post-test 1, T2:

post-test 2) × gesture condition (ICON, ATTENT) × word class (nouns, verbs) as within-subjects factors, and group (SLI, LM, AM) as between-subjects factor for the dependent variables comprehension and naming. Greenhouse–Geisser corrections were applied where necessary. Significant main effects were resolved by pairwise comparisons using Bonferroni corrections. *P*-values were considered significant at the $p < .05$ level. To quantify differences among learning conditions, test times and word class effect sizes (partial eta squared: η_p^2) were calculated. Data were analyzed using IBM SPSS statistics version 21.

RESULTS

Omnibus 4-way analyses tested the effect of learning nouns and verbs under two gesture conditions (ICON vs. ATTENT) over time (pre-test, post-test 1, post-test 2) in children with SLI and TD children matched for language (LM) and age (AM). As no effect of gender on learning performance was found, data are collapsed in all analyses. We first report on the comprehension task before turning to the naming task. Mean scores and standard deviations (SD) are shown in Tables 4 and 5, respectively. An overview of main and interaction effects is given in Table 6.

Comprehension

The ANOVA confirmed a main effect of test time ($F(1{\cdot}61,91{\cdot}93) = 300{\cdot}79$, $p < .001$, $\eta_p^2 = .84$). As expected, scores were significantly higher at T2 (M% ± SD: 85 ± 13) than at T1 (58 ± 22; $p < .001$), which in turn were significantly higher than at T0 (21 ± 13; $p < .001$). No between-groups effect emerged ($F(2,57) = 2{\cdot}39$, $p = .10$, $\eta_p^2 = .08$), indicating that children of all groups were able to learn the new words. There was a significant main effect of word class ($F(1,57) = 16{\cdot}07$, $p < .001$, $\eta_p^2 = .22$), which was modified by significant interactions time × word class ($F(2,114) = 8{\cdot}12$, $p = .001$, $\eta_p^2 = .12$), and time × word class × group ($F(4,114) = 5{\cdot}01$, $p = .001$, $\eta_p^2 = .15$). As our research focuses on gesture condition rather than word class per se, we did not follow up these effects.

Importantly, comprehension varied by gesture condition, as revealed by a significant main effect ($F(1,57) = 5{\cdot}67$, $p = .02$, $\eta_p^2 = .09$). Overall, children demonstrated better comprehension of words presented with ICON than ATTENT gestures. No significant interaction time × gesture condition was found ($F(2,114) = 2{\cdot}20$, $p = .11$, $\eta_p^2 = .04$), indicating that condition similarly influenced comprehension performance over time. Critically, comprehension did not differ between conditions at pre-test ($t(59) = .19$, $p = .84$). No significant interaction condition × word class was found ($F(1,57) = 0{\cdot}24$, $p = .62$, $\eta_p^2 = .01$), demonstrating that gesture condition affected learning of both nouns and verbs. There was no significant

TABLE 4. *Iconic vs. attention-directing gestures: mean percentage (+SD) of correct responses on the comprehension test*

	T0 (pre-test)				T1 (post-test 1)				T2 (post-test 2)			
	ICON		ATTENT		ICON		ATTENT		ICON		ATTENT	
	Nouns	Verbs	Nouns	Verbs	Nouns	Verbs	Nouns	Verbs	Nouns	Verbs	Nouns	Verbs
SLI	25 (23)	25 (28)	15 (20)	20 (22)	62 (42)	57 (29)	42 (43)	42 (44)	95 (15)	72 (34)	87 (22)	57 (33)
LM	17 (29)	17 (24)	20 (25)	30 (29)	77 (30)	47 (37)	77 (30)	47 (34)	100 (0)	87 (22)	92 (18)	77 (25)
AM	21 (19)	23 (26)	23 (26)	18 (25)	68 (31)	64 (29)	68 (29)	43 (28)	88 (19)	88 (19)	86 (22)	87 (20)

TABLE 5. *Iconic vs. attention-directing gestures: mean percentage (+SD) of correct responses on the naming test*

	T0 (pre-test)				T1 (post-test 1)				T2 (post-test 2)			
	ICON		ATTENT		ICON		ATTENT		ICON		ATTENT	
	Nouns	Verbs	Nouns	Verbs	Nouns	Verbs	Nouns	Verbs	Nouns	Verbs	Nouns	Verbs
SLI	0 (0)	0 (0)	0 (0)	0 (0)	2 (11)	15 (28)	2 (11)	5 (15)	30 (37)	22 (34)	15 (23)	32 (37)
LM	0 (0)	0 (0)	0 (0)	0 (0)	19 (30)	22 (30)	5 (16)	8 (19)	50 (38)	27 (25)	27 (35)	30 (34)
AM	0 (0)	0 (0)	0 (0)	0 (0)	8 (18)	20 (19)	6 (13)	15 (20)	36 (26)	48 (31)	31 (31)	39 (33)

TABLE 6. *Iconic vs. attention-directing gestures: main and interaction effects (significant results in bold)*

Omnibus analyses	Comprehension test	Naming test
Main effects		
time	**$F(1{\cdot}61,91{\cdot}93) = 300{\cdot}79$, $p < {\cdot}001$, $\eta_p^2 = {\cdot}84$**	**$F(1{\cdot}59,87{\cdot}61) = 95{\cdot}20$, $p < {\cdot}001$, $\eta_p^2 = {\cdot}63$**
condition	**$F(1,57) = 5{\cdot}67$, $p = {\cdot}02$, $\eta_p^2 = {\cdot}09$**	**$F(1,55) = 7{\cdot}18$, $p = {\cdot}01$, $\eta_p^2 = {\cdot}12$**
word class	**$F(1,57) = 16{\cdot}07$, $p < {\cdot}001$, $\eta_p^2 = {\cdot}22$**	$F(1,55) = 2{\cdot}65$, $p = {\cdot}11$, $\eta_p^2 = {\cdot}05$
group (between-subjects)	$F(2,57) = 2{\cdot}39$, $p = {\cdot}10$, $\eta_p^2 = {\cdot}08$	$F(2,55) = 2{\cdot}79$, $p = {\cdot}07$, $\eta_p^2 = {\cdot}09$
Interaction effects		
time * group	$F(4,114) = 1{\cdot}18$, $p = {\cdot}32$, $\eta_p^2 = {\cdot}04$	$F(3{\cdot}18,87{\cdot}61) = 1{\cdot}67$, $p = {\cdot}17$, $\eta_p^2 = {\cdot}06$
condition * group	$F(2,57) = 2{\cdot}04$, $p = {\cdot}14$, $\eta_p^2 = {\cdot}07$	$F(2,55) = 0{\cdot}93$, $p = {\cdot}40$, $\eta_p^2 = {\cdot}03$
word class * group	$F(2,57) = 1{\cdot}02$, $p = {\cdot}37$, $\eta_p^2 = {\cdot}03$	$F(2,55) = 2{\cdot}28$, $p = {\cdot}11$, $\eta_p^2 = {\cdot}08$
time * condition	$F(2,114) = 2{\cdot}20$, $p = {\cdot}11$, $\eta_p^2 = {\cdot}04$	$F(1{\cdot}50,82{\cdot}72) = 2{\cdot}54$, $p = {\cdot}10$, $\eta_p^2 = {\cdot}04$
time * condition * group	$F(4,114) = 0{\cdot}99$, $p = {\cdot}41$, $\eta_p^2 = {\cdot}03$	$F(3{\cdot}01,82{\cdot}72) = 0{\cdot}53$, $p = {\cdot}66$, $\eta_p^2 = {\cdot}02$
time * word class	**$F(2,114) = 8{\cdot}12$, $p = {\cdot}001$, $\eta_p^2 = {\cdot}12$**	$F(1{\cdot}61,88{\cdot}52) = 1{\cdot}99$, $p = {\cdot}15$, $\eta_p^2 = {\cdot}03$
time * word class * group	**$F(4,114) = 5{\cdot}01$, $p = {\cdot}001$, $\eta_p^2 = {\cdot}15$**	$F(3{\cdot}22,88{\cdot}52) = 1{\cdot}42$, $p = {\cdot}24$, $\eta_p^2 = {\cdot}05$
condition * word class	$F(1,57) = 0{\cdot}24$, $p = {\cdot}62$, $\eta_p^2 = {\cdot}01$	$F(1,55) = 1{\cdot}79$, $p = {\cdot}19$, $\eta_p^2 = {\cdot}03$
condition * word class * group	$F(2,57) = 0{\cdot}85$, $p = {\cdot}43$, $\eta_p^2 = {\cdot}03$	$F(2,55) = 1{\cdot}26$, $p = {\cdot}29$, $\eta_p^2 = {\cdot}04$
time * condition * word class	$F(1{\cdot}75,100) = 0{\cdot}51$, $p = {\cdot}57$, $\eta_p^2 = {\cdot}01$	**$F(1{\cdot}46,80{\cdot}18) = 4{\cdot}54$, $p = {\cdot}02$, $\eta_p^2 = {\cdot}08$**
time * condition * word class * group	$F(3{\cdot}50,100) = 0{\cdot}81$, $p = {\cdot}51$, $\eta_p^2 = {\cdot}03$	$F(2{\cdot}91,80{\cdot}18) = 1{\cdot}45$, $p = {\cdot}23$, $\eta_p^2 = {\cdot}05$

interaction condition × group ($F(2,57) = 2{\cdot}04$, $p = {\cdot}14$, $\eta_p^2 = {\cdot}07$), and so no evidence that children with SLI responded to the learning conditions differently from TD children.

Naming

For naming, the ANOVA revealed a significant main effect of test time ($F(1{\cdot}59,87{\cdot}61) = 95{\cdot}20$, $p < {\cdot}001$, $\eta_p^2 = {\cdot}63$). Post-hoc testing showed a steady increase in naming performance: T0 (M% ± SD = 0) < T1 (10 ± 13; $p < {\cdot}001$) < T2 (32 ± 21; $p < {\cdot}001$). No between-groups effect arose ($F(2,55) = 2{\cdot}79$, $p = {\cdot}07$, $\eta_p^2 = {\cdot}09$), demonstrating that children of all groups improved naming performance over time.

A significant main effect of gesture condition was revealed ($F(1,55) = 7{\cdot}18$, $p = {\cdot}01$, $\eta_p^2 = {\cdot}12$), such that children named more words presented with ICON gestures than with ATTENT gestures. No significant interaction test time × gesture condition was found ($F(1{\cdot}50,82{\cdot}72) = 2{\cdot}54$, $p = {\cdot}10$, $\eta_p^2 = {\cdot}04$). Importantly, naming performance at pre-test did not differ by condition, as no child was able to name any of the target words (M% ± SD = 0). Thus, gesture condition affected performance at both post-test times.

However, the main effects were qualified by a significant interaction test time × gesture condition × word class ($F(1{\cdot}46,80{\cdot}18) = 4{\cdot}54$, $p = {\cdot}02$, $\eta_p^2 = {\cdot}08$). Separate analyses indicated that at T1 children named more verbs trained with ICON gestures (19 ± 26) than verbs trained with ATTENT gestures (9 ± 18, $t(57) = 2{\cdot}58$, $p = {\cdot}012$), but not nouns (ICON 9 ± 21, ATTENT 5 ± 13, $t(57) = 1{\cdot}65$, $p = {\cdot}10$) , whilst at T2 more nouns trained with ICON gestures (38 ± 34) were named than nouns trained with ATTENT gestures (24 ± 30, $t(57) = 2{\cdot}67$, $p = {\cdot}010$), but not verbs (ICON 33 ± 32, ATTENT 34 ± 34, $t(57) = -0{\cdot}26$, $p = {\cdot}79$). The interaction is illustrated in Figure 2. Notably, there were no significant interactions gesture condition × group ($F(2,55) = 0{\cdot}93$, $p = {\cdot}40$, $\eta_p^2 = {\cdot}03$), and test time × gesture condition × word class × group ($F(2{\cdot}91,80{\cdot}18) = 1{\cdot}45$, $p = {\cdot}23$, $\eta_p^2 = {\cdot}05$), reflecting the fact that children with SLI and TD children responded similarly to the learning conditions.

Control condition

In order to address a potential confound, namely the use of a constant gesture as a control condition (as opposed to different iconic gestures), an additional experiment with 18 TD preschool children (mean age 4;9) was conducted. In this analysis, we compared the same iconic gestures as in the first experiment to an equal number of item-specific, dynamic non-iconic gestures. Training and assessments were identical. Only the ATTENT gesture was substituted with item-specific arbitrary (ARBITR) gestures, which showed no resemblance to the respective referents. Mean scores and standard deviations in terms of comprehension and naming are shown in Table 7. Scores were higher in the ICON gesture condition, except for naming performance at T1, suggesting that, overall, children demonstrated better comprehension and naming of words presented with ICON gestures. Due to the small sample size, the descriptive advantage failed to reach significance. However, the results point in the same direction as in the main experiment.

DISCUSSION

Previous research has shown that observing iconic gesture helps TD children as well as children with SLI learn new words. However, studies mostly

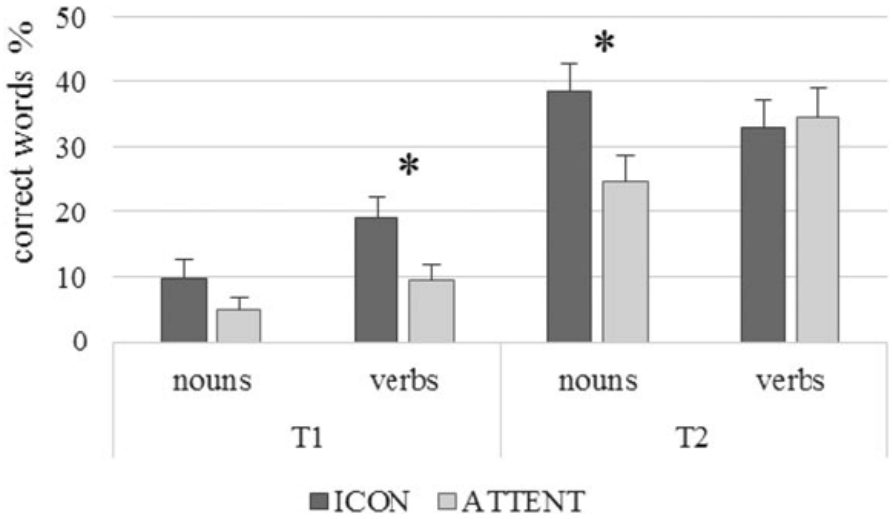


Fig. 2. Proportion of correct naming responses (mean and standard error) across word classes in the iconic and attention-directing gesture learning condition at two post-test times (groups collapsed).

TABLE 7. *Iconic vs. arbitrary gestures (n = 18): mean percentage (+SD) of correct responses on the comprehension and naming test (nouns and verbs collapsed)*

	T0 (pre-test)		T1 (post-test 1)		T2 (post-test 2)	
	ICON	ARBITR	ICON	ARBITR	ICON	ARBITR
Comprehension	21 (14)	21 (16)	64 (19)	61 (12)	84 (20)	77 (22)
	$t(17) = 0{\cdot}00$, $p = 1{\cdot}0$		$t(17) = 0{\cdot}50$, $p = {\cdot}62$		$t(17) = 1{\cdot}09$, $p = {\cdot}28$	
Naming	0 (0)	0 (0)	13 (15)	15 (15)	37 (28)	30 (24)
			$t(17) = -0{\cdot}48$, $p = {\cdot}63$		$t(17) = 1{\cdot}64$, $p = {\cdot}12$	

compared word learning with and without the help of gestures. To rule out the possibility that children may simply have profited from the increased attention they paid to words paired with gestures, the present study set out to investigate word learning under two gesture conditions: (a) simultaneous presentation of words and iconic gestures vs. (b) presentation of words and attention-directing gestures. In addition, this study expands previous research by including children both with and without language impairment. Word learning (comprehension and naming of nouns and verbs) was assessed after the first training session (fast mapping) and after training completion (retention). First, there was a steady increase in comprehension and naming performance over time, demonstrating that

both TD and language impaired children were able to learn the new words. Beyond the demonstration of a general learning achievement, our study yielded two main findings: (i) observing iconic gestures improved learning to a greater extent than observing non-iconic gestures did; and (ii) the iconic gesture advantage was similar in TD and language impaired children. We will now review and discuss these findings.

The role of iconic gestures in word learning

Former research revealed that words are learned better while simultaneously seeing iconic gestures than with mere verbal input in TD children (e.g. Capone & McGregor, 2005; McGregor *et al.*, 2009; Munro *et al.*, 2011) and children with SLI (Ellis Weismer & Hesketh, 1993; Lüke & Ritterfeld, 2014). In this study, we compared the effects of observing iconic and non-iconic (attention-directing and arbitrary gestures) and demonstrated that the iconic gesture advantage holds true not only over mere verbal learning. In accordance with our first hypothesis, children learned words (nouns and verbs) presented with iconic gestures better than with a gesture that guided their attention towards the new words. This was the case for both comprehension and naming during initial learning (fast mapping) and retention.

Our results confirm the findings of Capone Singleton (2012), who showed enhanced word learning with iconic shape gestures over pointing gestures in TD toddlers. The results strongly suggest that iconic gestures provide an advantage over and above focusing children's attention. Why do iconic gestures provide an advantage for word learning? Both iconic and non-meaningful gestures (like pointing and attention-directing) can focus children's attention and lead to increased salience of the target word, which in turn supports the child's fast mapping and retention of the lexical form. Indeed, the fact that children comprehended the majority of words presented with attention-directing gestures at post-test 2 (81%), suggests that to some extent attention-directing gestures do benefit learning. Iconic gestures, however, contribute to word learning in a different way than just making children more engaged and attentive (Mumford & Kita, 2014; Novack *et al.*, 2015). Rather, it appears that specific features of iconic gestures contribute to effective word learning. Our results indicate that children make use of information from observing iconic gestures for processing and encoding new lexical forms. Along with Capone Singleton (2012), our results demonstrate that iconic gestures may help children strengthen the links to the lexical form. In this way, watching iconic gestures prompts rich encoding and makes word learning more efficient.

Findings of a fast mapping study with TD children indicated that arbitrary gestures might also benefit word learning (Lüke & Ritterfeld,

2014). To address this issue, we conducted an additional experiment, this time comparing iconic gestures to an equal number of arbitrary gestures. The results revealed a numerical advantage for the iconic gestures, even though the small sample size did not allow for detection of potential effects of this magnitude. Thus, the additional analysis suggests that the difference in word learning may remain even when we compare iconic and arbitrary gestures. Therefore, it appears that it is the iconicity of the gestures (that is the resemblance to the referent), rather than the item-specific encoding of both auditory and visual information to a lexical form, that helps learning. Further research is needed to substantiate these findings and to determine in more detail which specific pieces of information constitute the iconic gesture advantage.

In addition, the finding that iconic gestures enhance word learning more than attention-directing gestures do can be specified further with regard to word class and stage of word learning. Our results show that iconic gestures contributed to word learning at different points in time. As we paired learning nouns with shape gestures and verbs with combined manner and path gestures, our results shed light on how readily accessible different types of iconic gesture are for preschool children. For comprehension, children's responses did not differ with respect to word class, i.e. children learned both nouns and verbs better with iconic gestures. For naming, as the more demanding task, the impact of iconic gestures varied with regard to word class and test time. During initial learning, children were better at naming verbs trained with iconic gestures than verbs trained with attention-directing gestures, but there was no advantage of either gesture type in noun naming. Conversely, during slow mapping, children named nouns, but not verbs, better when trained with iconic gestures. Thus, for naming during initial learning, the path–manner gestures paired with verb learning caused the iconic advantage, whereas for retention this advantage was due to the shape gestures used for noun learning. Apparently, observing iconic path–manner gestures for movements has an immediate impact, while observing iconic shape gestures for objects has an effect in the longer term.

These results find confirmation in the recent literature. Research has shown that recognizing iconicity in gesture types emerges at different points in time in development. While children at age two can learn from iconic gestures that convey action information, it is only at age three that they are able to recognize iconic gestures representing the shape properties of objects (Hodges *et al.*, 2015; Novack *et al.*, 2015). Probably, iconic gestures of actions provide multiple types of information and are more closely aligned to the body than iconic shape gestures. Therefore, it might be easier to map movement gestures onto actions, but cognitively more demanding to map shape gestures onto objects (Hodges *et al.*, 2015). Our

results support these findings, suggesting a difference in the timing of the impact on word learning. Providing iconic movement gestures apparently aids learning in the initial stage of word learning. In contrast, iconic gestures conveying shape information seem to particularly assist retention. These findings are also in line with the results of Lüke and Ritterfeld (2014), who showed that iconic shape gestures did not enhance word learning at the fast mapping interval; only during slow mapping were children able to benefit from shape information.

To summarize: as predicted, our results demonstrate that observing iconic co-speech gestures more effectively enhances comprehension and naming of new words than does observing attention-directing or arbitrary gestures. Iconic gestures prompt richer encoding and make word learning more efficient for both the initial stage of learning and for retention of the words. Moreover, expecting children to benefit from iconic shape gestures for noun learning and from iconic manner–path gestures for verb learning proved true. However, these effects manifest themselves in different stages of word learning. During the initial stage, iconic gestures enhanced performance in verb naming, while noun naming improved at the slow mapping interval. Children make use of information provided by iconic gestures to establish and strengthen the connections to the lexical form, and this effect differs depending on the stage of word learning and word class.

The role of iconic gestures in children with and without SLI

So far, we have shown that seeing iconic gestures improves word learning in children with and without SLI. Do children with SLI derive a differential (i.e. smaller or bigger) benefit as is sometimes suggested? Evidence is not uniform in this respect. Only one study compared word learning (at the fast mapping interval) with iconic gestures in children with SLI and TD children. Ellis Weismer and Hesketh (1993) reported that comprehension of both groups similarly improved. This is also true for the children in the present study. Children of all groups (children with SLI, language-matched TD, and age-matched TD children) more effectively benefited from iconic gestures for word learning than from attention-directing gestures, for both comprehension and naming. The patterns of response were similar across groups, and no particular benefit for children with SLI emerged. This is in line with a meta-analysis (Hostetter, 2011) which found no evidence that gestures are more valuable for special populations such as children with developmental disorders. Although considered a special group of language learners, children with SLI are capable of perceiving information in iconic gestures, to integrate information conveyed by gesture and speech, and to use this information for word

learning. With regard to our second hypothesis, we conclude that children with SLI benefit from iconic gestures for mapping a lexical form and semantics in a similar way and to a similar degree as TD children do.

Limitations

Some limitations of this study need to be mentioned. First, in face-to-face interaction it is not possible to continuously control for children's attention. Although we spared no effort in making children observe the gestures during training, we could not ascertain that they did so consistently. Second, it is sometimes suggested that children yield higher rates of learning when they perform the gestures themselves (the enactment effect; Engelkamp & Cohen, 1991), rather than merely observing another person gesturing. In this study, children were not encouraged to enact the gestures. Had we done so, learning patterns might have changed. Future research is needed to investigate a possible added value of enacting gestures during word learning.

CONCLUSIONS AND PERSPECTIVES

The results presented here have important implications for both research and practice. Iconic gestures can be regarded as a suitable tool for teaching words to children with and without SLI in clinical contexts and educational settings. Shape gestures in particular qualify as a support for consolidation of nouns. For verbs, it may be advisable to employ combined manner and path gestures during the initial phase of learning. This study furthers our knowledge on how iconic gestures support word learning in children with and without SLI. Our findings help to attain a more differentiated understanding of the role of specific iconic gestures in the course of learning. This will allow tailoring of therapeutic and educational procedures to children with and without SLI.

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Impact of iconic gestures on naming of taught words in children with specific language impairment

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Abstract

The current study tested the hypothesis that learning new words while simultaneously observing iconic gestures benefits word naming in children with specific language impairment (SLI). Children with SLI as well as typically developing children named words learned with iconic gestures better than words learned with a gesture that merely guides children's attention to the taught words when the respective gestures were provided as naming cues during assessment. Naming cues improved naming performance in the iconic condition. Children with SLI showing low abilities in noun naming in particular appear to benefit from learning words paired with iconic gestures.

Index Terms: word, iconic gesture, attention-directing gesture, semantic representation, language impairment

1. Introduction

A popular assumption poses that iconic gesture aids language acquisition in children. The view that the resemblance between the gesture and the referent might ease language learning, and word learning in particular, is attractive also for clinicians in the field if speech and language therapy. It rests on the idea that iconic gestures are intuitively accessible and less arbitrary than spoken symbols. They capture properties of a referent and thus serve as semantic enrichment cues and aid recall (Capone & McGregor, 2005; Capone Singleton, 2012, Hostetter, 2011). This might ease the complex mapping processes required for word learning. During word learning, the child initially creates a preliminary and incomplete representation of the new form-referent link, this is often referred to as fast mapping. Progressively, through slow mapping the child establishes an advanced representation with data from different sources, gesture among them (Alt & Suddarth, 2012, Rohlfing, 2013). Starting by age three, children are able to understand the meaning of iconic co-speech gestures (Stanfield, Williamson & Özçalişkan, 2014) and might strengthen semantic representations of the referents by observing iconic gesture.

Indeed, research suggests that iconic co-speech gestures enhance word learning when a suitable gesture is paired with a word. This has been shown in young typically developing (TD) children (e.g. Capone & McGregor 2005; Capone Singleton, 2012; McGregor, Rohlfing, Bean & Marschner, 2009), in children learning a second language (e.g. Tellier 2008) and also in clinical groups such as children with Down Syndrome (Foreman & Crews 1998; Launonen, 2003). According to Capone & McGregor (2005) iconic gestures serve to enrich semantic representation of words. They showed that toddlers benefit from iconic shape gestures rather than iconic function gestures for naming taught novel nouns. The two iconic gesture conditions were superior to a condition where no gesture was provided (Capone & McGregor, 2005) and similarly, to a condition where a point gesture was provided, that is a gesture that does not exemplify a semantic feature (Capone Singleton, 2012). Concluding from her findings, Capone Singleton (2012) suggests the use of iconic cues in word learning interventions for children with language impairments.

Children with SLI show deficiencies in language development despite otherwise normal development. Their language skills often resemble those of younger children (Alt & Suddarth, 2012; Bishop, 2006). Among other difficulty, vocabulary acquisition and word learning are major problems. Both fast and slow mapping abilities are concerned: word knowledge emerges only slowly and is fragile relative to peers, including semantic representations (Alt & Plante, 2006; Kan & Windsor, 2010). Retrieving words poses a particular challenge. As failure in word retrieval has been related to weak semantic representation (Capone & McGregor, 2005; Sheng & McGregor, 2010), the use of iconic co-speech gesture may prove as useful semantic enrichment cues potentially supporting word learning in children with SLI.

Pioneering work of Ellis Weismer & Hesketh (1993) has shown that in a fast mapping task children with SLI as well as TD children comprehended novel words better when the words were trained with accompanying iconic gestures, compared to a condition where the novel words were trained without gestures. In the group with SLI, children who had demonstrated comprehension deficits in the language profiles tended to benefit more from iconic gestures. For naming the novel words no difference was found.

Lüke & Ritterfeld (in press) extended this work. To go beyond fast mapping, they introduced novel words as names for cartoon characters. Effects of iconic gestures on learning of these names were compared to a no-gesture condition. For fast mapping, no advantages for the iconic gesture condition were found. However, during extended word learning, children showed a gesture benefit for naming the novel names, but not for comprehension.

The current study drew on these findings. A word learning study was conducted, employing a repeated measures within-subjects design under two learning conditions: the new words were trained with iconic gestures or an attention-directing gesture, respectively, in the form of a uniformly raised forefinger as control condition. Such a gesture guides listeners to attend to parts of the accompanying speech and thus serves a metacognitive purpose. This approach allowed me to compare two conditions where both the spoken word and a gesture have to be mapped onto the referent. I was particularly interested in word naming after a period of slow mapping because it is important to be able to retrieve a word when it is needed in daily life. Word naming is usually assessed in a binary way (named or not named). In this study, I graded the naming task by applying the respective gestures as a cue when the child had failed to name the referent accurately, arguing that this scaffolding might enable children with weaker semantic representations to successful naming (Capone & McGregor, 2005; Capone Singleton, 2012).

The study asked a) whether there is an effect of gesture condition on naming of taught words, b) in case of a naming failure, whether there is an effect of gesture cues on naming performance and c) whether there are relations between performance on the naming task and the language profiles

(word comprehension and production in particular) of children with SLI and children matched for age and language, respectively. Based on the literature, I expected that learning in the iconic gesture condition would lead to better naming performance and that iconic gestures (but not the attention-directing gesture) as cues for naming would improve performance in case of previous naming failure. As for potential correlations between children's language profiles and performance on the word naming task, no clear hypothesis could be formulated.

2. Methods

2.1 Participants

Participants in the study were monolingual German speaking children who showed normal general development including nonverbal cognition: 18 children with SLI (mean age 4;6 years), 18 TD children matched for language (LM; 3;3 years) and 15 TD children matched for age and gender (AM; 4;5 years). Children with SLI had formerly been diagnosed by the child's speech and language clinicians. The diagnoses and information regarding language and nonverbal cognitive skills were confirmed by standardized measures administered before training. Nonverbal cognitive ability was within normal range for all children. A range of language skills was assessed using norm-referenced tests (table 1: raw score and percentile group means and SD of all measures and between-group comparisons). In all language measures, children with SLI differed from AM (see table 1: raw and percentile scores) and matched LM (see table 1: raw scores). To be included in the SLI group, children had to perform more than one SD below the mean on at least three of the language subtests administered.

Table1. *Participant information: group means (standard deviation) of cognitive and language measures*

		AM (n = 15)		**SLI** (n = 18)		**LM** (n = 18)
Independent Variable	Scores	M (SD)	*p*	M (SD)	*p*	M (SD)
Age	Months	53 (3,2)	ns	54 (7,9)	***	39 (1,4)
Nonverbal Cognition	Percentile	87 (16,3)	ns	73 (24,8)	ns	60 (22,1)
Grammar comprehension	Percentile	44 (25,9)	**	15 (17,1)		56 (26,1)
	Raw score	6 (2,8)		4 (2,1)	ns	4 (1,8)
Noun comprehension	Percentile	56 (32,8)	**	24 (25,5)		67 (28,3)
	Raw score	17 (1,4)		15 (2,1)	ns	16 (2,1)
Verb comprehension	Percentile	64 (31)	***	27 (27)		78 (21,7)
	Raw score	16 (2,3)		13 (3)	ns	14 (2,6)
Noun naming	Percentile	58 (27,8)	***	17 (17)		76 (23,6)
	Raw score	16 (2,2)		10 (4,2)	ns	12 (2,3)
Verb naming	Percentile	60 (39,2)	***	4 (12,2)	no normative data	
	Raw score	12 (3,3)		6 (3,4)	ns	7 (2,2)
Word definition	Percentile	46 (24,3)	***	17 (15,7)		42 (16,1)
	Raw score	10 (2,3)		6 (3,2)	ns	7 (1,6)
Nonword repetition	Percentile	63 (30,2)	***	15 (20,4)		45 (28,2)
	Raw score	10 (4,4)		4 (3,2)	ns	5 (2,8)

Note: AM = age matched children; SLI = children with SLI; LM = language matched children
ns = non siginificant; ** $p < .01$; *** $p < .001$

2.2 Target words and learning conditions

Target words consisted of 12 low-frequency German words, which are unfamiliar for children of this age, nouns and verbs of equal shares. Nouns represented animal species (e.g. *a rail*); verbs were intransitive and represented movement types (e.g. *to stalk*). All items had been tested in a pre-study in terms of appropriateness in a word learning study. Moreover, pilot work had shown that for TD children of this age learning 12 words attained an optimal performance range. For children with SLI and LM children however, learning 12 words led to mental overload and reduced attention during training and to floor effects in learning assessments. For these children, learning 8 new words turned out appropriate. I therefore decided to train unequal numbers of target words and accordingly express data as percentages.

Children learned the words under two conditions: In the iconic gesture condition spoken words were paired by a gesture that mirrored a striking feature in shape or performance of the respective referent. As control condition, an attention-directing gesture in the form of a raised forefinger was used. Such a gesture does not exemplify a semantic feature of the referent but rather serves a metacognitive purpose by guiding listeners' attention to the new words. Thus, children with SLI and LM learned 2 nouns and 2 verbs under both conditions resulting in 8 words in total, whereas AM children learned 3 nouns and 3 verbs under both conditions resulting in 12 words altogether. The words to be learned in the iconic and the attention-directing gesture condition were counterbalanced across children.

2.3 Procedure

Children were seen individually for six sessions. The first two sessions comprised assessment of nonverbal cognition, language abilities and words to be taught during the training. Subsequently, three training sessions were conducted two to three days apart each. The target words were introduced during the first session and repeated in the remaining two sessions, following a standard protocol such that children heard the words repeatedly during bookreading and play. Spoken target words were paired with either the iconic or the attention-directing gesture. We had created a story containing all target words and illustrated the story in a story book. The story served as basis for the training. Children heard the words 17 to 20 times per session, 57 times in total. Naming of taught words was assessed two to three days after training completion. The child was asked "What is this?" and "What is she doing?", respectively. In case of failing to accurately name the target word, the child was encouraged to think again of the word label. If the child still failed naming, the respective gesture the target word had been paired with during the training (either iconic or attention-directing) was provided as a cue: "Look": GESTURE. The gesture cue was determined by the respective learning condition. Correct responses scored one point each. A response was rated as correct if the child produced the target word or a morphological variant within a multiple-word response.

2.4 Data analysis

To determine whether iconic gestures served to improve naming auf taught words across groups, we applied a 2 × 2 repeated measure ANOVA with the factors learning condition (iconic = ICON, attention-directing = ATTENT) and naming cue (without cue, with cue) as within-subjects factors and group as between-subjects factor and post hoc Bonferroni tests. The dependent variable was percentage of accurately named taught words. Bonferroni corrections resolved significant main effects and interactions. To explore an iconic gesture benefit on naming performance the benefit (benefitCOND) was defined as the mean difference of words learned with ICON gestures minus words learned with ATTENT gestures (e.g. benefitCOND = 2 implies the child learned two more words in the ICON than in the ATTENT condition). This value was correlated with children's' language profiles assessed before the training.

3. Results

3.1 Accuracy of naming responses

There was a significant main effect of cue, $F(1, 48) = 41{,}59$, $p < .001$, $\eta_p^2 = .46$ with children of all groups performing better when a gesture cue was provided during naming than without a cue. There was also a main effect of learning condition $F(1, 48) = 13{,}05$, $p = .001$, $\eta_p^2 = .21$ with learning words in the ICON condition being superior to learning words in the ATTENT condition. The main effects were modified by a significant cue × condition interaction, $F(1, 48) = 23{,}84$, $p < .001$, $\eta_p^2 = .33$, such that children of all groups named words learned in the ICON condition better than words learned in the ATTENT condition (ICON/ATTENT: SLI: 43,2/26,3, LM: 56,9/34,7, AM: 54,4/31,1) when a naming cue was provided during the naming task (significance levels: SLI $p = .018$, LM $p = .004$, AM $p = .001$) but not when no naming cue was provided (ICON/ATTENT: SLI: 26,3/22,2, LM: 38,8/33,3, AM: 35,5/28,8). Naming cues improved naming performance in the ICON condition, but not in the ATTENT condition, except marginally for children with SLI, $t(17) = 1.84$, $p = .083$, $d = .48$. Main and interaction effects are depicted in figure 1.

3.2 Correlations between language profiles and benefit of gesture condition on naming

A moderate negative correlation was found between benefitCOND and noun naming performance in children with SLI ($r_p = -.553$, $p = .017$), explaining 30% of the variance, indicating that children with SLI and lower abilities in naming of nouns on a standardized measure benefit more from learning words with iconic gestures. Note that the gesture benefit in naming was not correlated with additional standardized measures, therefore noun naming performance was an independent predictor and only in children with SLI.

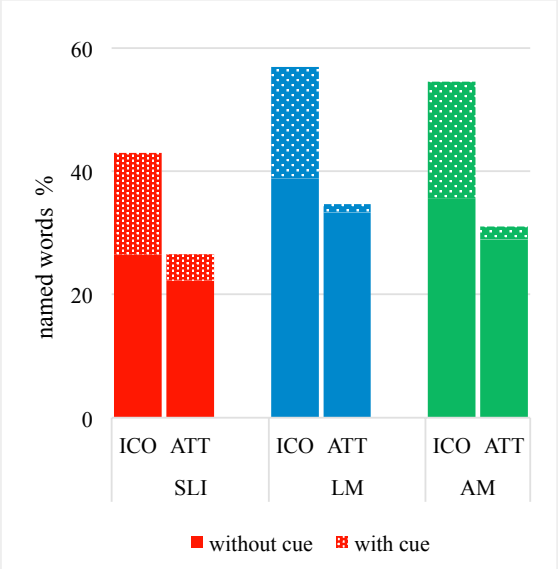

Figure 1: *Percentage of accurately named words in the iconic (ICO) vs. attention-directing (ATT) learning condition across groups (SLI, language matched, age matched children).*
Solid fill colors: naming performance without cue; textured parts: naming performance with gesture cue provided)

4. Discussion

Does learning new words paired with iconic gestures help children name taught words after a period of slow mapping compared to learning words with an attention-directing co-speech gesture that does not exemplify a semantic feature of the referent? To my knowledge, effects of iconic and noniconic (i.e. attention-directing) gestures on naming have not yet been compared in children with SLI and TD children. The hypothesis was that learning words paired with iconic gestures would facilitate naming in children of all groups. Moreover, in case of failure in naming taught words, I expected children to improve naming performance when providing the iconic gesture as a cue during word retrieval.

Despite a descriptive advantage for naming words trained with iconic gestures, the difference to naming words trained with an attention-directing gesture failed to reach significance. A difference between the two gesture conditions only emerged when children were provided the respective gestures (iconic or attention-directing) in case of

previous failure in naming the taught word. In that case, children of all groups named words learned with iconic gestures significantly better. Therefore, the prediction that learning new words together with iconic gestures would be superior to learning words with an attention-directing gesture cannot be fully supported. An iconic gesture benefit for naming novel names had been found in the study of Lüke & Ritterfeld (in press) for children with SLI. The authors confirm earlier findings regarding TD children, that iconic gestures enrich semantic representations and thus facilitate naming of words. Why was this not the case for the children in this study? On the one hand, scaffolding effects of iconic gestures on naming taught words in this study might be negligible due to input manipulations differing from those in the abovementioned study, such as word type (novel vs. real words, names vs. nouns and verbs), number of taught words (9 vs. 8) or exposure to target words (46 vs. 57) as well as due to differing participants' language profiles (e.g. monolingual and bilingual vs. merely monolingual). Alternatively, a gesture that leads children to attend to new words presented may also be supportive. In the study of Lüke & Ritterfeld (in press), the control condition was merely an absence of gesture, whereas here an attention-directing gesture condition was applied allowing to compare word learning under two gesture conditions. Therefore, it appears that children in this study derived some benefit from observing both iconic and attention-directing gestures during word learning. Both types of gesture guide children's attention to the intended target words, thus increasing salience of the words and facilitating learning. The iconic gesture additionally exemplifies a striking feature of the referent; in this way, it aids children to some extent to enrich semantic representation of the referent.

As word learning is an ongoing process, this study assessed children's naming performance not only in terms of named or not named, but instead graded assessment of learning achievement by providing a cue in case of failure in naming. The cues provided were the respective gestures the word had been paired with during the training. Similar to Capone Singleton (2012, 288) cued naming was viewed as providing some scaffolding "to tap word representations that were just on the threshold of activation". Concerning my second hypothesis, as expected, naming performance of all children increased when a gesture cue was provided during the naming task, compared to naming without cue. Providing iconic gesture cues more effectively facilitated word naming than did providing cues to merely direct children's' attention. Here, the characteristic capacity of iconic gestures as to embody semantic features of a referent becomes evident. Observing the respective iconic gesture during word retrieval appears to activate word representations and thus to ease the access to the referent's word form. This enabled children with SLI as well as TD children, who had previously failed to name the taught words, to significantly improve naming. Interestingly, and contrary to my expectation, there was a marginally significant small to medium effect of the attention-directing gesture cue on naming performance in children with SLI, indicating that to some degree these children also took advantage from a gesture that does not exemplify semantic features of the referent. Apparently, the gesture by itself brings implicit word knowledge to the surface, therefore facilitating the access to the word form, even when the gesture does not make any semantic information available.

No clear hypothesis had been formulated regarding the question which children might benefit from learning words paired with iconic gestures for naming. An earlier finding from a fast mapping task (Ellis Weismer & Hesketh, 1993) had pointed towards a possible iconic gesture benefit for comprehension of taught words in children with SLI evidencing low comprehension capacities. In my study, not fast mapping skills, but naming performance after a period of slow mapping was assessed. For TD children, no correlation patterns emerged. However for children with SLI, there was a moderate negative correlation between the iconic gesture benefit and performance in naming nouns in a standardized measure, accounting for 30% of the variance. Although not predicted, this finding does not come as a surprise. It implies that specifically language impaired children with lower word production skills may take advantage of learning words paired with iconic gestures for naming and thus enrich semantic representations. By contrast, children with SLI and better abilities in word production do not. Instead, they rather benefit from increased salience of the referents by merely bringing their attention to the new words. Note that this finding refers to children with SLI, but not to TD children.

Although this was not a question of the study, it was found that children with SLI exhibited patterns in word learning similar to those of TD children when learning requirements were adapted to children's language profiles. The notion that children with SLI might derive a particular benefit from learning words paired with iconic gestures (as compared to TD children) is not supported by the data. Instead, on a group level, the benefit of observing iconic gestures during word learning for naming taught words was quite similar across groups. As mentioned above, performance of children with SLI merely differed from performance of TD children insofar as children with SLI took some advantage of observing the attention-directing gesture during word retrieval to improve naming performance. From a clinical perspective, it can be concluded that both the iconic and the attentional factors of gesture contribute to word learning in children with SLI. Therefore, gestures should necessarily be considered in word learning interventions. On the one hand they function as a visual support to store new words and to enrich representations, on the other hand they assist children retrieve taught words.

5. Conclusions

The notion that the characteristic property of iconic gestures, namely the resemblance between the gesture and the referent, facilitates word learning in children with SLI as well as in TD children is partially supported by this study. For naming newly taught words after a period of training, it appears that observing both iconic gestures and gestures bringing children's attention to a particular referent contribute to word learning. Questions remain as to whether it is the iconicity of the gesture rather than the attention paid to the new word that served to ease the mapping processes, assessed here through naming tasks without and with gesture cues after some period of slow mapping. Children with SLI evidencing low abilities in noun naming in particular appear to benefit from learning words paired with iconic gestures. Observing iconic gestures exemplifying a semantic feature of the referent during word retrieval qualified as effective facilitation in word-naming tasks. To shed further light on how iconic gesture contributes to word learning in children with and without SLI future work will include additional outcome measures above and beyond naming, such as comprehension and word definition tasks.

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Research Article

With Some Help From Others' Hands: Iconic Gesture Helps Semantic Learning in Children With Specific Language Impairment

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Purpose: Semantic learning under 2 co-speech gesture conditions was investigated in children with specific language impairment (SLI) and typically developing (TD) children. Learning was analyzed between conditions.
Method: Twenty children with SLI (aged 4 years), 20 TD children matched for age, and 20 TD children matched for language scores were taught rare nouns and verbs. Children heard the target words while seeing either iconic gestures illustrating a property of the referent or a control gesture focusing children's attention on the word. Following training, children were asked to define the words' meaning. Responses were coded for semantic information provided on each word.
Results: Performance of the SLI and age-matched groups proved superior to that of the language-matched group. Overall, children defined more words taught with iconic gestures than words taught with attention-getting gestures. However, only children with SLI, but not TD children, provided more semantic information on each word taught with iconic gestures. Performance did not differ in terms of word class.
Conclusions: Results suggest that iconic co-speech gestures help both children with and without SLI learn new words but, in particular, assist children with SLI understand and reflect the words' meaning.

Children with specific language impairment (SLI) show language deficits in the absence of concomitant sensory impairments, intellectual disability, neurological diagnoses, or other developmental concerns (Bishop, 2014; Leonard, 2014). Typically, impaired grammar and phonology are considered the outstanding clinical features. However, children with SLI may also face various lexical–semantic difficulties, including problems with receptive and expressive vocabulary, lexical processing, and word learning (for a detailed review, see Kan & Windsor, 2010; Nation, 2014).

Lexical–Semantic Knowledge in Children With SLI

Word learning is a complex task and involves mapping a word's lexical form (syllables, phonemes) and semantics (the meaning) and eventually establishing a firm link between the lexical form and the semantic representation. With several exposures to a word in rich contexts, the child is able to organize and store information on the word's form and its meaning and to acquire a profound and stable knowledge of the word (Gupta, 2005; He & Arunachalam, 2017; McGregor, Sheng, & Ball, 2007).

Building a diverse and deep vocabulary is crucial to communicate and learn successfully. McGregor and colleagues differentiated between vocabulary breadth, referring to how many words a child knows, and depth, indicating how well the words are known (McGregor, Oleson, Bahnsen, & Duff, 2013). Common ways to estimate breadth or diversity are word-to-picture matching and naming tasks, which give a general picture of a child's vocabulary skill (Paul & Norbury, 2012). These tasks tap acquiring the link between a lexical form and its meaning, which, in our work, we refer to as lexical learning; thereby, the demands on children's semanticsystem are low (Nation, 2014). Assessing semantic learning, that is, the acquisition of understanding the word's meaning or depth of word knowledge, usually requires children to provide semantic associations, word-to-word relationships, judgments about the meaning of words, and answers to questions on word meaning or word definitions (McGregor & Duff, 2015).

Current research points toward deficits in both the quantity and quality of word knowledge in children with

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SLI (Nation, 2014). Apart from deficits in vocabulary breadth, they have been shown to differ from typically developing (TD) peers across a range of tasks investigating vocabulary depth. For example, children with SLI exhibited reduced vocabulary depth as assessed through a word definition task (McGregor et al., 2013). Alt, Plante, and Creusere (2004) found that children with SLI recognized fewer semantic features of novel objects and actions. Nash and Donaldson (2005) revealed poorer learning of the meaning of low-frequency nouns by analyzing children's word definitions and responses to "yes/no" questions on the words' meaning. Moreover, children with SLI were reported to provide reduced semantic content in oral definitions of common nouns (Marinellie & Johnson, 2002) as well as to generate fewer semantic associations to words (Sheng & McGregor, 2010), reflecting a poor understanding of the meaning. Typically, performance of children with SLI in terms of vocabulary depth resembles that of younger TD children matched on vocabulary measures (e.g., Laws et al., 2015; Nash & Donaldson, 2005).

In summary, many children with SLI are poor at word learning and exhibit vocabulary deficits as well as sparse meaning representations and weak connectivity between items relative to peers. It is assumed that vocabulary deficits manifest themselves in limited word comprehension and naming; yet, these deficiencies reflect underlying immaturities in semantic learning and impoverished semantic representations (McGregor, Newman, Reilly, & Capone, 2002; Nash & Donaldson, 2005; Nation, 2014). Given that deficits persist in many children with SLI and may even become more marked with age (McGregor et al., 2013; Stothard, Snowling, Bishop, Chipchase, & Kaplan, 1998), means to facilitate word learning are required.

Iconic Gesture as a Resource in Word Learning in Children With and Without SLI

Word learning has been reported to improve when children are presented iconic gestures while simultaneously hearing new words. These are gestures that represent objects and events due to the visual resemblance to the referent and thereby help convey meaning aspects (Novack, Goldin-Meadow, & Woodward, 2015; Özyürek, 2000). Imagine, for example, someone talking about a species of antelope called beisa, thereby conducting an upward movement at the head with both hands. In order to learn from this gesture, one has to be able to understand that the movement refers to a referent's property—in this case, the beisa's long horns. Children have been shown to learn from iconic gesture early in life. By the age of 2 years, they are able to access gesture information (Novack et al., 2015), and by the ages of 3;5 to 4, the ability to derive meaning from iconic gesture is in place (Namy, Campbell, & Tomasello, 2004; Stanfield, Williamson, & Özçalişkan, 2014; Tolar, Lederberg, Gokhale, & Tomasello, 2008). Gestures depicting the action of a referent, for example, showing *flying* while flapping sideways extended arms, are easier to understand than gestures depicting perceptual properties, such as the aforementioned upward movement of the hands in the head area illustrating the antelope's horns (Hodges, Özçalişkan, & Williamson, 2015; Tolar et al., 2008).

In order to benefit from co-speech gesture for word learning, a child has to be able to process and integrate both the gestural and auditory information, a skill that is acquired by the age of 3 years (Sekine, Sowden, & Kita, 2015). Regarding lexical learning, that is, acquiring the link between a new lexical form and its meaning, learning of novel words (for objects, spatial terms, and proper names) has been shown to improve in both TD children (Capone & McGregor, 2005) and children with SLI (Ellis Weismer & Hesketh, 1993; Lüke & Ritterfeld, 2014) when children simultaneously were presented iconic co-speech gestures rather than mere verbal input. Moreover, iconic gestures were demonstrated to boost lexical learning over other types of co-speech gestures. For example, TD children named more novel objects taught with iconic shape gestures than objects taught with pointing gestures, which direct attention to the referent (Capone Singleton, 2012). Similarly, learning of nouns and verbs (as assessed through word-to-picture matching and naming tasks) was more effective in children, both with and without SLI, when words were presented with iconic gestures rather than with gestures that guided children's attention toward a heard word (Vogt & Kauschke, 2017). Preschool children may also benefit from arbitrary gestures, which show no resemblance to the referent (Lüke & Ritterfeld, 2014). However, once the ability to recognize iconicity in gestures is in place, there seems to be an advantage of iconic gesture over arbitrary gesture for mapping a lexical form and meaning (Marentette & Nicoladis 2011; Vogt & Kauschke, 2017).

In summary, there is increasing evidence that observing iconic gesture improves lexical learning. It may lead to enhanced comprehension and naming performance of words taught with iconic gestures over mere verbal input and over other types of gesture. Children, both with and without SLI, make use of iconic gesture information for encoding new lexical forms and in this way strengthen the link between form and meaning, and they do so in a similar way and to a similar degree (Vogt & Kauschke, 2017).

Studies have also found gains through iconic co-speech gesture on measures of acquiring semantic attributes associated with a lexical form (semantic learning) in TD children. McGregor, Rohlfing, Bean, and Marschner (2009) compared toddlers' acquisition of the preposition *under* with and without iconic gestures. A gesture advantage emerged when children were tested with untrained materials, reflecting a more robust and abstract knowledge of the meaning. Moreover, seeing iconic gestures assisted preschool children focus on a particular aspect of novel verbs and thus facilitated acquiring the meaning (Goodrich & Hudson Kam, 2009; Mumford & Kita 2014). Yet, generalization of an iconic gesture effect on semantic learning is limited. For one thing, studies mainly focused on the initial mapping of a lexical form and meaning (fast mapping). However, semantic learning proceeds over time after repeated exposures to a word, enabling children to build up a more complete meaning

representation (Capone Singleton, 2012). So far, there is little evidence of how observing iconic gesture influences meaning acquisition over time. Second, stimuli were not representative of the words children acquire (one preposition). Finally, studies merely focused on TD children. As yet, the impact of iconic gestures on semantic learning in children with SLI is still unexplored. Indeed, a potential iconic gesture effect might be particularly pronounced in populations with language impairment, as research has found that children with SLI benefit more from gesture input for pragmatic comprehension (Kirk, Pine, & Ryder, 2011; Lavelli, Barachetti, & Florit, 2015) and that language and gesture are more closely associated in children with SLI than in TD children (Botting, Riches, Gaynor, & Morgan, 2010; Lavelli & Majorano, 2016). However, for comprehension and naming of newly acquired words, Vogt and Kauschke (2017) did not find a differential effect when words were taught either with iconic or attention-getting gestures. Rather, both TD children and children with SLI similarly benefited from seeing iconic gestures.

We address this gap, including children with SLI in the study. In studies with SLI populations, it is appropriate to consider two control groups of TD children (matched for chronological age and for linguistic age) in order to investigate how far patterns of learning and performance differ from age-matched TD peers but resemble that of younger children with still limited linguistic abilities.

The Current Study

The main aim of this study was to evaluate the relative effect of iconic co-speech gesture on semantic learning. By use of a word definition task, we investigate whether manipulation in gesture input differentially influences semantic learning. The study extends previous studies on the effect of observing iconic co-speech gesture on semantic learning in that we (a) include children with SLI and two control groups of TD children (matched for chronological age and vocabulary age), (b) include a period of training, and (c) teach children nouns and verbs of very low frequency under two co-speech gesture conditions (iconic and attention-getting) and investigate semantic learning following training.

The study intended to compare the effect of iconic gesture versus attention-getting gesture on semantic learning (in terms of breadth and depth) of two word classes (nouns and verbs) after a training period in children with SLI and two TD control groups. Moreover, we aimed at comparing learning performance across groups as well as between word classes. In a within-subject design, children with SLI and TD children of the same age and gender as well as younger TD children who were matched to the children with SLI for vocabulary scores were taught new words for objects and actions. In the experimental condition, words were presented with iconic gestures. An attention-getting gesture served as a control condition. Such a gesture guides listeners to attend to particular parts of the utterance and increases word salience but does not convey semantic information about the referent. Following the training period (three sessions), children were asked to define the taught words. Based on McGregor et al. (2013), responses were analyzed for both breadth of vocabulary knowledge in terms of the number of target words children were able to define and depth as estimated from the quality of definitions the children produced.

We hypothesized that children with SLI and younger TD children would perform on a similar level concerning the quantity and quality of word definitions provided. Based on the literature documenting an iconic advantage over mere verbal learning and over other types of co-speech gestures on lexical learning, we expected children to define more words and provide more detailed information on each word when taught with iconic gestures. This should apply to nouns (words for objects) and to verbs (words for actions). In contrast, gestures that do not provide any meaning information but rather guide children's attention were expected to have relatively less influence on semantic learning. In addition, we sought to determine whether children with and without SLI would be similarly or differentially affected by the gesture conditions. We did not make a firm prediction here because both patterns have been reported before.

Method

Participants

This study is based on the same sample as described in Vogt and Kauschke (2017). Although the former publication deals with the impact of iconic co-speech gestures on word comprehension and word production abilities, this study focuses on semantic abilities as estimated from the quality of the definitions children produced.

In total, 60 children (aged 3–6 years) with SLI and TD children from middle class backgrounds in the Frankfurt and Hamburg areas in Germany were recruited. Parents gave informed consent to the study and answered a questionnaire focusing on the child's general and language development. All children were monolingual German speakers and showed normal general development, including physical, sensory, and nonverbal cognitive skills.

Standardized assessments concerning language and nonverbal cognitive skills were administered before training. Nonverbal cognitive ability in the SLI and age-matched (AM) group was measured using the Coloured Progressive Matrices (Raven, Bulheller, & Häcker, 2010). In children younger than 3;9, the subtest "Muster legen" (patterns identification) of the Wiener Entwicklungstest (Kastner-Koller & Deimann, 2012) was used. Only children with nonverbal cognitive skills in the normal range were included in the study.

Language skills were assessed using validated norm-referenced tests frequently used in clinical practice. The following skills were assessed: (a) grammar comprehension using the Test for Reception of Grammar–German Version (Fox, 2006), (b) receptive and expressive vocabulary (nouns and verbs) using subtests of the Patholinguistische Diagnostik bei Sprachentwicklungsstörungen (Kauschke &

Siegmüller, 2010), (c) word definition using a subtest of the Wiener Entwicklungstest (Kastner-Koller & Deimann, 2012), and (d) nonword repetition using a subtest of the Sprachentwicklungstest für drei- bis fünfjährige Kinder (Grimm, 2010).

Children With SLI

Children had formerly received diagnoses of SLI from speech and language therapists. Detailed information regarding language skills and intervention was obtained through a therapist questionnaire. No treatment involved gestures. The diagnoses were confirmed by the assessments administered before training. A child met criteria for SLI if three or more of the language scores were more than 1 standard deviation below the mean. Five children who did not meet criteria were excluded from the study. All children exhibited expressive language impairment, 11 children also demonstrated receptive deficits (scores of more than 1 standard deviation below the normative mean on the Test for Reception of Grammar–German Version and on at least one of the two word comprehension subtests).

Group-Matching Procedures

Each child in the SLI group was matched to two TD children: One TD child of the same chronological age (±9 months) and gender and one TD child who was younger but at a comparable level regarding language skills, in particular, matched on raw scores of word comprehension (±1 point out of 20). The matching procedures resulted in three groups:

1. 20 children with SLI (10 girls, 10 boys, mean age = 4;6),
2. 20 TD children of the same age and gender as the children with SLI (AM group: 10 girls, 10 boys, mean age = 4;5), and
3. 20 younger TD children (language-matched [LM] group: 11 girls, nine boys, mean age = 3;3).

The TD children exhibited at least normal-range performance on all language measures. Mean language scores of the children with SLI were significantly lower than scores of the AM children on all measures but did not differ from those of the LM children. Participant details (group means and standard deviations of the cognitive and language testing) are given in Table 1.

General Procedure

A word learning study was conducted teaching children unknown words under two learning conditions (within-subject design). Assessments and training took part within 2 weeks in a separate room in children's nurseries. Children were seen individually for six sessions of approximately 30 min each. The sessions were video-recorded (JVC camcorder HD Everio GZ-V515). Approval for the study was given by the University of Applied Sciences Fresenius Ethics Committee.

In the first two sessions, nonverbal cognition and language skills were assessed. Also, knowledge of the target words taught during the training was assessed. After 2–3 days, children received three training sessions 2–3 days apart each. The target words were introduced during the first session and repeated in the following two sessions. Each time, the spoken target words were paired with a gesture. Word learning was assessed 2–3 days after training completion (Figure 1).

Target Items

The target items consisted of six German nouns and six verbs. Nouns represented rare animal species; verbs were intransitive and represented unusual movement types. The target items were of very low frequency and were chosen from German dictionaries. If available, word frequency was determined by use of the corpus-based collection of the University of Leipzig (1998/2013). The words had been tested in TD 4-year-old and 5-year-old monolingual German children in a prestudy (n = 16). No child had been able to name any of the stimuli; assessment of comprehension had revealed correct responses to stimuli below chance level. In this study, as expected, the children did not know the target items as shown by a naming task and a word-to-picture matching task in the pretraining assessment. Lexical forms were monosyllabic or bisyllabic following the German trochaic prosodic pattern. All target items are given in Table 2, together with a complete list of the semantic properties focused on during the training.

A pilot study showed that TD children at the age of 4 years succeeded in learning 12 words within three training sessions. For children with SLI and younger children, however, learning 12 words caused mental overload, reduced children's attention during training, and led to floor effects in the assessments. Rather, learning eight new words proved to be adequate. On the other hand, use of eight new words resulted in ceiling effects for 4-year-old TD children. In order to avoid floor or ceiling effects, we concluded to train unequal numbers of target words (12 in the AM group, eight in the LM and SLI groups). Such a procedure is sometimes used in training studies with SLI and TD groups so as to be able to compare learning (e.g., Ellis Weismer & Hesketh, 1993). Note that the main aim of the study was to compare learning patterns between groups rather than the quantitative performance on the task.

Gesture Conditions

Words were taught under two gesture conditions. In the iconic condition (ICON), spoken stimuli were paired with a gesture that captured the shape of the animal (nouns) or the manner and path of the movement (verbs), respectively. Shape gestures had been shown to particularly support learning nouns (Capone & McGregor, 2005), but manner gestures aided children to interpret new verbs (Mumford & Kita, 2014). The gestures were dynamic, lasted for 1–2 s, and

Table 1. Participant details: Age and test performance (means and standard deviations).

Independent variable	Scores	AM (*n* = 20) *M* (*SD*)	*t* (AM vs. SLI)	SLI (*n* = 20) *M* (*SD*)	*t* (SLI vs. LM)	LM (*n* = 20) *M* (*SD*)
Age in months		53 (3)		54 (7)		39 (2)
Range		48–59		45–69		36–41
Nonverbal cognition	Percentile[a]	85 (18)	*p* = .163 *ns*	71 (25)	*p* = .307 *ns*	58 (20)
Grammar comprehension	Percentile	48 (29)	–4.24***	16 (16)		56 (25)
	Raw score	7.4 (3.1)		4.2 (2.1)	–0.56 *ns*	4.5 (1.7)
Noun comprehension	Percentile	52 (30)	–3.13**	24 (25)		64 (28)
	Raw score	17.7 (1.3)		15.6 (2.1)	–0.73 *ns*	16.1 (2.1)
Verb comprehension	Percentile	61 (30)	–3.35**	29 (29)		79 (20)
	Raw score	16.0 (2.2)		13.8 (3.0)	–0.28 *ns*	14.1 (2.5)
Noun naming	Percentile	58 (28)	–5.66***	16 (16)		74 (24)
	Raw score	16.2 (2.3)		10.6 (4.0)	–1.15 *ns*	11.8 (2.3)
Verb naming	Percentile	59 (41)	–5.65***	3 (11)	No normative data available	
	Raw score	11.9 (3.7)		6.2 (3.2)	–.85 *ns*	6.9 (2.1)
Word definition	Percentile	44 (24)	–3.93***	17 (15)		41 (15)
	Raw score	10.0 (2.4)		6.5 (3.2)	–1.12 *ns*	7.5 (1.5)
Nonword repetition	Percentile	64 (29)	–6.08***	15 (20)		42 (29)
	Raw score	10.6 (4.2)		4.0 (3.1)	–1.40 *ns*	5.5 (3.0)

Note. AM = age-matched; SLI = specific language impairment; LM = language-matched; *ns* = nonsignificant.

[a]Percentile: refers to a value on a scale of hundred (mean of 50 and *SD* of 34) that indicates the percentage of a distribution that is equal or below.

**$p < .01$. ***$p < .001$.

were performed with the hands in front of the investigator's upper body or in the head region. A gesture-to-referent matching task with 24 adult students (aged 19–24 years) confirmed that adults were able to match the gestures to the respective referents in 83%–98% on average. In the control condition, spoken stimuli were paired with a uniform attention-getting (ATTENT) gesture in the form of a raised forefinger in front of the upper body. Target stimuli, together with their associated iconic gestures, are given in Table 2. Children learned half of the target words (half nouns and half verbs) in the ICON condition and the other half in the ATTENT condition (half nouns and half verbs). Words in the ICON and ATTENT gesture conditions were counterbalanced for order across children but remained paired with the referent throughout training.

Training Procedure

Children were taught the target words following a standard protocol as detailed in a comprehensive training manual (see Table 3 for an overview of the structure of training sessions). All words were presented in the first training session and repeated in the next two sessions, 57 times each. Spoken words were paired with either an ICON or ATTENT gesture. Children were allowed, but not encouraged, to imitate the gestures; yet, their gesturing was not responded to. As preschool children are familiar with storybook reading and benefit from repeatedly hearing stories for word learning (Horst, Parsons, & Bryan, 2011), we created a story and illustrated it in a picture book. The story included all target words and served as a basis for the training.

Each training session was organized in three phases. In Phase 1 (storybook reading), each child listened to the story read aloud by the investigator. The child heard the target words (nine times during the first two sessions, but six times during the third session) but received no further explanations of the meaning. Phase 2 consisted of a throwing game, wizardry, or animal feeding, respectively. Each target word was presented five times. Modeling procedures were used to elaborate each word's meaning while displaying a picture of the referent. Elaborations focused on appearance, environment, favorite food and special attributes of the objects (animal species) and location, realization, function, and distinctive features of the actions (movement types) as shown in Table 2. During Phase 3, child and investigator

Figure 1. Study design.

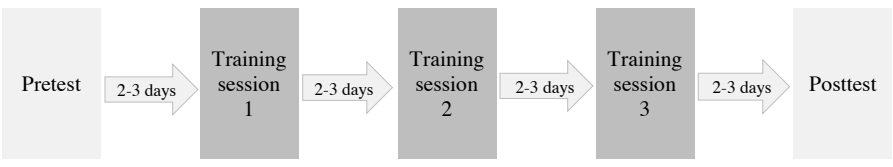
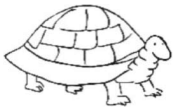
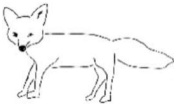


Table 2. Target items: Pictures, characteristic properties, and associated gestures (*iconic features*) (Drawings: Copyright © 2013 Joy Katzmarzik leap4joy graphics; reprinted with permission).

Nouns		Verbs	
	Iconic gesture		**Iconic gesture**
die Ralle ("rail")	  *long legs,* long beak, white feathers, by the water, eats earthworms	staksen ("to stalk")	  *to lift up one's legs,* across a small river, across the stones, to fall into water, careful
die Gopher ("gopher")	  *wrinkly neck,* turtle species, in the snow, moves slowly, eats salad and carrots	retschen ("to chute backward")	  *to chute backward,* sit on one's booty, down the hill, in the snow, hurt the booty
die Beisa ("beisa")	  *long horns,* antelope species, harmless, by the fence, eats hay	hüpeln ("to stand up on tiptoes")	  *to stand up,* to be taller, to see over the fence, to stretch, to stand on tiptoes
der Alk ("auk")	  *prominent beak,* penguin species, in the meadow, black and white, eats fish	tippeln ("to tippytoe")	  *to move fast, with both legs,* to have plenty of brawn, children, football training
der Fennek ("fennec")	  *ears sticking out,* fox species, in the desert, can run fast, eats leaves	krauchen ("to creep")	  *to crawl sideways,* on one's stomach, on the floor, to smudge, under the fence
der Numbat ("numbat")	  *pouch,* similar to kangaroo, baby, prominent tail, eats bugs	gliddern ("to slide")	  *to slide forward,* over the frozen surface, ice skates, to slip and fall, with one's feet,

(*table continues*)

Table 2. *(Continued).*

Nouns		Verbs	
	Iconic gesture		**Iconic gesture**
Control condition: attention-getting gesture			

jointly watched a video on a tablet computer where an actor tells the above-mentioned story. Target words were presented six times each but were never elicited during the training.

Assessment

To assess semantic knowledge after training completion, children were asked to define the target words. Following a general definitional question, they were asked probe questions aiming at the properties of target objects (animals) and actions (movement types) imparted during the training. To ensure that the task was understood, children received a model of a common word prior to the task. The following questions relevant to all objects and actions, respectively, were used to elicit the most information that children could express:

(a) Each target was introduced with a general question, for objects, "Can you tell me what an X is?" and for actions, "Can you tell me what Xing is?"

(b) Next, children were provided with the prompt, "Can you tell me anything else about X/Xing?"

(c) Children were then asked, "How does an X look?" or "What do you have to do in order to Xing?"

(d) Finally, they were asked, "What does an X eat?" or "How does Xing work?"

Table 3. Content and structure of each training session.

Activity	Time	Number of presentations of target items
Picture book reading Investigator reads story live-voice to the child. Summary of story: A boy called Jan spots a track. He is curious who might have left it and decides to follow the track. On his way, he meets several unfamiliar animals. Each of them reveals what to do next in order to be able to further follow the track and find the answer. Materials: picture book	LM/SLI group: 6 min (Sessions 1 and 2) 5 min (Session 3) AM group: 7 min (Sessions 1 and 2) 6 min (Session 3)	9 (Sessions 1 and 2) 6 (Session 3)
Play Investigator uses modeling procedures to specify characteristic properties of the referents (appearance, environment, food and special attributes of animal species, location, realization, and distinctive features of movement types). Examples: Noun *Beisa* (*beisa*): "Here you see a *beisa*. The *beisa* loves to eat hay. We can feed the *beisa*. Hello *beisa,* are you hungry? Yes? So, let`s give the *beisa* some hay." Verb *staksen* (*to stalk*): "Now we can *stalk*. To *stalk* we have to lift our legs. Look how I *stalk*. Can you also *stalk*? Hey, great how you *stalk*!" Materials: pictures of the respective referents (see Table 2) and different toys (e.g., ball, magic wand, small stones, crayons)	LM/SLI group: 7 min AM group: 9 min	5
Video clip Child and investigator jointly watch a video clip in which an actor tells the story, thereby performing the respective gestures. Materials: tablet computer	LM/SLI group: 3 min AM group: 4:20 min	6

Note. AM = age-matched; SLI = specific language impairment; LM = language-matched.

Questions were not asked if appropriate information had been given in the responses before. Responses were video-recorded in addition to taking written notes.

Scoring

Each appropriate response to a question was given one point, regardless if the child gave the response to the general definitional questions (1 and 2) or to the more specific questions (3 and 4). Information was scored correct when it was semantically appropriate and had been focused on during the training; for example, "the beisa eats hay and has horns" was given two points. A complete list of appropriate responses is given in Table 3. Inappropriate responses (e.g., "the beisa eats earthworms") and children's inventions (e.g., "the beisa is friends with the rail") were scored as incorrect. Errors in phonology and grammar were not taken into account; for example, the response "*Beisa Heu esse*" *("beisa hay eat")* was given one point.

Given children's young age and limited language skills, a child might know the meaning of target words although she is not able to verbally respond to the questions. Indeed, some children responded to the questions concerning the meaning of target verbs by acting out the respective movement type rather than to verbally describe them. For definitions of target nouns, however, all children provided verbal responses merely. Accordingly, we applied a broader scoring procedure for the verb targets: If the child acted out the adequate movement explicitly (e.g., stood up on its tiptoes when asked to tell what *hüpeln* is), this nonverbal response was scored as correct. In contrast, we assumed providing the respective iconic gestures (e.g., an upward movement at the head with both hands in order to define *Beisa*) as an inappropriate response to a definitional question and hence scored it as incorrect.

To evaluate scoring reliability, 100% of the responses were coded via videotape by a second coder who was trained by the first author and was blind to the gesture condition and to the child's group membership. The mean point-to-point agreement was 91% for determining correct responses. Cases of disagreement were identified and resolved by discussion.

Data Analysis

In order to address both breadth and depth of word knowledge as dependent variables, we conducted two analyses (following McGregor et al., 2013):

1. Breadth: the number of target words that children were able to define with at least one adequate piece of information on the word's meaning. In other words, we calculated the number of target words that was scored with at least one point, resulting in eight or 12 points at maximum, depending on the total number of taught words. Because unequal numbers of words were taught across the groups, analyses were based on percentages.
2. Depth: the amount of correct meaning information provided by the child for each target, that is, all points given for the responses (see "scoring section") were summed up and divided by the number of taught words; that is, the mean number of pieces of information provided per word (five at maximum) was calculated.

Mixed-design analyses of variance (ANOVAs) were run with the independent variables gesture condition (ICON, ATTENT) and word class (nouns, verbs) as within-subject factors and group (SLI, LM, AM) as between-subjects factor for the dependent variables breadth and depth of semantic knowledge. In order to control for variables other than vocabulary, we initially included age, nonverbal cognition, and grammar comprehension as covariates. However, as none of the variables showed as significant, we removed them from consideration. Significant main effects were resolved by pairwise comparisons using Bonferroni corrections. The p values were considered significant at the $p < .05$ level. To quantify differences among gesture conditions and word classes, effect sizes (partial eta squared η_p^2 and Pearson's correlation coefficient r) were calculated. Effect sizes were interpreted as small ($\eta_p^2 > .01$, $r > .1$), medium ($\eta_p^2 > .06$, $r > .3$), and large ($\eta_p^2 > .14$, $r > .5$) (Cohen, 1988; Richardson, 2011). Data were analyzed using IBM SPSS statistics Version 21.

Results

Mixed-design ANOVAs tested the effect of two co-speech gesture conditions (ICON vs. ATTENT) on learning nouns and verbs in children with SLI, younger TD children matched to children with SLI for language scores (LM), and TD children matched for chronological age (AM). Word knowledge in terms of both breadth and depth (dependent variables) was investigated. Keep in mind that unequal numbers of words were taught across the groups (12 in the AM group, eight in the LM and SLI groups).

Breadth: How Many Words Were Children Able to Define?

Concerning breadth scores (in terms of the percentage of target words children defined), the ANOVA revealed a significant large difference among the groups, $F(2, 57) = 6.47$, $p = .003$, $\eta_p^2 = .18$. Pairwise comparisons using Bonferroni tests indicated that breadth scores of LM children ($M\% \pm SD$: 37 ± 31) were significantly poorer than those of the AM group (68 ± 20, $p = .002$) and tended to be poorer than scores of the SLI group (58 ± 30, $p = .07$). Scores of the SLI and AM groups did not significantly differ ($p = .74$). Hence, the younger TD children defined relatively fewer words than the older TD children and marginally fewer words than the children with SLI did. In the LM group, there was a high number of children ($n = 8$) scoring at floor level (below 20% correct responses). Three children in the SLI group and one child in the AM group showed floor effects.

A significant medium main effect of gesture condition on breadth scores, $F(1, 57) = 7.61$, $p = .008$, $\eta_p^2 = .12$, reflected the fact that breadth scores of words taught with

ICON gestures ($M\% \pm SE$: 59 ± 4.2) were higher than scores of words taught with ATTENT gestures (50 ± 3.6). There was no significant main effect of word class, $F(1, 57) = .28$, $p = .60$, indicating that the number of taught nouns (for objects) children defined correctly ($M\% \pm SE$: 54 ± 4.4) did not differ from the number of verbs (for actions; $M\% \pm SE$: 56 ± 3.9).[1] No interaction effects emerged.[2] Group means are presented in Table 4.

Depth: How Well Did the Children Define the Words?

We next analyzed the depth of semantic knowledge, that is, how well the children defined the taught words. To this end, we calculated the pieces of meaning information children provided on each target word. Group means are given in Table 5. A mixed-design ANOVA with gesture condition (ICON vs. ATTENT) and word class (nouns and verbs) as the repeated measures and study group (SLI vs. LM vs. AM) as the between-subjects factor showed a significant large main effect of group, $F(2, 57) = 7.61$, $p = .001$, $\eta_p^2 = .21$. Post hoc comparisons using Bonferroni tests indicated that LM children (M pieces of information per word ± SD: 0.57 ± 0.57) scored significantly lower than AM children (1.58 ± 0.90, $p = .001$) and children with SLI (1.22 ± 0.96, $p = .05$). SLI depth scores did not significantly differ from AM means ($p = .52$). Thus, the LM children gave relatively fewer information on the taught words than the AM group and fewer information than the SLI group.

There was a significant medium effect of gesture condition, $F(1, 57) = 5.19$, $p = .03$, $\eta_p^2 = .08$, indicating that, overall, children provided more information on words taught with ICON gestures (M pieces of information ± SE: 1.22 ± 0.13) than on words taught with ATTENT gestures (1.02 ± 0.10). This was qualified by a trend toward a significant medium interaction effect, Condition × Group, $F(2, 57) = 2.94$, $p = .06$, $\eta_p^2 = .09$, revealing that the effect of gesture condition tended to vary across the groups. Inspection of the interaction graph (see Figure 2) suggested that, regarding depth scores, the SLI group in particular benefited from teaching words with ICON gestures. The interaction was clarified by planned comparisons between the gesture conditions in each group. In the SLI group, scores for words taught with ICON gestures ($M \pm SD$: 1.45 ± 1.18) were significantly higher than scores for words taught with ATTENT gestures (0.98 ± 0.81), $t(19) = 3.02$, $p = .007$, $r = .56$, representing a large effect. However, there were no differences between the gesture conditions in the LM group (ICON 0.68 ± 0.73, ATTENT 0.45 ± 0.53), $t(19) = 1.74$, $p = .09$, and in the AM group (ICON 1.54 ± 1.02, ATTENT 1.61 ± 0.95), $t(19) = -0.41$, $p = .68$).

No effect of word class emerged, $F(1, 57) = 0.09$, $p = .76$, indicating that children were equally able to provide information on taught nouns and verbs.[1] No further significant interactions emerged.[2]

To summarize, performance of the SLI group proved superior to that of the LM group regarding both breadth and depth scores. Overall, children defined more words taught with ICON gestures than words taught with ATTENT gestures. In terms of depth scores, the gesture effect varied across the groups. Results suggest that depth of word knowledge was influenced more strongly by gesture condition in children with SLI than it was in TD children.

Discussion

This study compared the impact of two co-speech gesture conditions on semantic learning after a period of training in preschool children with SLI, TD children matched for chronological age and gender, and younger TD children matched for vocabulary skill. To this end, we conducted a word learning study teaching children previously unknown nouns and verbs under an iconic condition and an attention-getting gesture condition. Because of children's differing linguistic abilities, unequal numbers of target words were taught in order to avoid floor or ceiling effects (12 in the AM group, eight in the LM and SLI groups). Following training, children's definitions of the taught words were scored for how many words children were able to define (breadth) and how well they defined the words (depth). We first discuss group differences in performance before we turn to our main research question, namely, the effect of gesture condition on children's semantic learning. Finally, we discuss the effect of word class.

Semantic Learning in Children With and Without SLI

Performance across the groups significantly differed. In terms of breadth, the younger TD children defined relatively fewer words than the older TD children and marginally fewer words than the children with SLI did, whereas relative performance of the two latter groups did not differ significantly. Regarding depth, similarly, the younger TD children gave comparatively fewer information on the words' meaning than the older TD and effectively fewer information than the SLI group. Again, relative performance of children with SLI did not differ significantly from performance of age-matched TD children.

Considering that the SLI and the younger TD group were matched for vocabulary measures (comprehension in particular, but naming and word definition skills were comparable, too) and were taught the same number of target words during the training, we expected the children to perform similarly well on the definition task. However, the high number of LM children scoring at floor level reveals that the task was too difficult for them. They defined marginally fewer target words and provided less information on each word's meaning than the children with SLI did. Our outcome

[1]Note that there were significant effects of word class on breadth and depth scores in favor of nouns over verbs when nonverbal performance of the actions were not accepted as a correct response. Yet, scoring mere verbal responses only did not change the results in terms of performance across the groups and gesture condition.

[2]Nonparametric tests (Kruskal–Wallis, Mann–Whitney, and Wilcoxon) led to similar results.

Table 4. Descriptive data and statistical results of breadth scores: Percentage of target words known (significant results in bold).

Breadth scores						Statistical results				
Descriptive data						Effects	*df*	*F*	*p*	η_p^2
		ICON		ATTENT		Group	**2, 57**	**6.47**	**.003**	**.18**
		Nouns	Verbs	Nouns	Verbs					
SLI	*M* (*SD*)	70 (41)	62 (39)	47 (41)	52 (30)	Gesture condition	**1, 57**	**7.61**	**.008**	**.12**
	Min–max	0–100	0–100	0–100	0–100					
LM	*M* (*SD*)	37 (39)	50 (45)	35 (46)	27 (37)	Gesture condition × Group	2, 57	2.34	.11	.07
	Min–max	0–100	0–100	0–100	0–100					
AM	*M* (*SD*)	61 (36)	74 (21)	69 (26)	68 (29)	Word class	1, 57	0.28	.60	.001
	Min–max	0–100	33–100	0–100	0–100					

Note. AM = age-matched; SLI = specific language impairment; LM = language-matched; ICON = iconic condition; ATTENT = attention-getting condition.

measure required children to define newly acquired words and to respond to questions on the meaning of these words. Given that the younger TD children in this study were only 3 years old, it is possible that children knew the meaning of the target words but did not cope with the metalinguistic demand and were not able to express their knowledge. However, children of this age should be highly familiar with adults' questions on meaning and properties of referents. Moreover, LM children performed similarly to the SLI group in a word definition subtest used in the pretraining assessment (see Table 1). Thus, this study suggests that semantic learning is a relative strength in children with SLI as compared to younger TD children with comparable vocabulary age in that they defined marginally more words and acquired a deeper semantic understanding than the younger TD children.

Taking into account that children with SLI were taught fewer words than age-matched TD children, despite a descriptive advantage of the age-matched TD children, relative performance did not significantly differ from that of children with SLI regarding both breadth and depth scores.

To some extent, this finding challenges earlier research showing that children with SLI perform comparably to vocabulary-matched, younger TD children on semantic measures (e.g., Laws et al., 2015; Nash & Donaldson, 2005) but poorer than TD children of the same age (e.g., Alt et al., 2004; Marinellie & Johnson, 2002; Nash & Donaldson, 2005; Sheng & McGregor, 2010). Certainly, in this study comparability of performance between age-matched TD children and children with SLI is limited due to differing numbers of target words taught during the training (12 words in the AM group, eight words in the SLI group). Nevertheless, the results are encouraging as they reveal that children with SLI can effectively acquire the meaning of new words when requirements are adapted to their linguistic abilities. Teaching children with SLI a moderate number of new words by providing multiple exposures to the words in a rich and structured leaning context yielded adequate gains in semantic learning. Findings of Loftus, Coyne, McCoach, Zipoli, and Pullen (2010) point in a similar direction. They showed that, with additional vocabulary instruction in small groups, kindergarten children with low levels of vocabulary acquired nearly as many words as their peers with higher levels.

Effect of Gesture Condition on Children's Responses

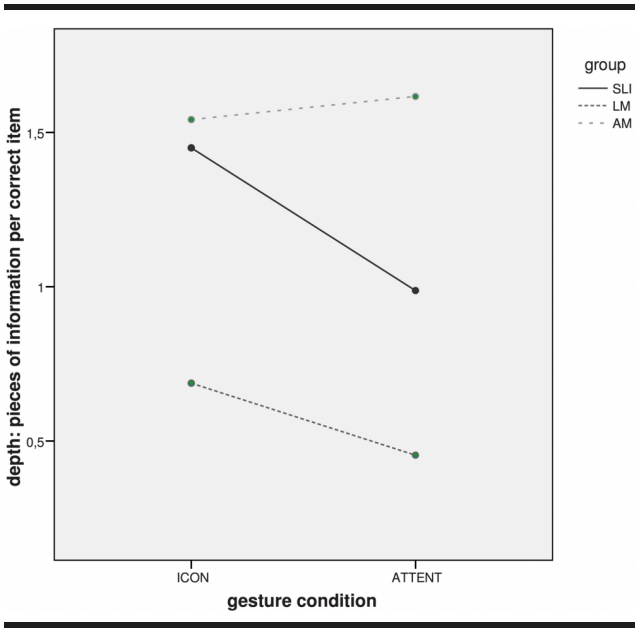
The main focus of our study was to examine whether children make use of information provided by iconic gestures for semantic learning. Specifically, we asked whether semantic knowledge of target words would differ regarding how many words children were able to define (breadth)

Table 5. Descriptive data and statistical results of *depth* scores: Pieces of information provided on each target word (significant results in bold).

Depth scores						Statistical results				
Descriptive data						Effects	*df*	*F*	*p*	η_p^2
		ICON		ATTENT		Group	**2, 57**	**7.61**	**.001**	**.21**
		Nouns	Verbs	Nouns	Verbs					
SLI	*M* (*SD*)	1.4 (1.3)	1.4 (1.4)	0.9 (1.0)	1.1 (0.9)	Gesture condition	**1, 57**	**5.19**	**.03**	**.08**
	Min–max	0–4	0–4	0–4	0–3					
LM	*M* (*SD*)	0.7 (0.9)	0.7 (0.8)	0.6 (0.9)	0.3 (0.5)	Gesture condition × Group	2, 57	2.94	.06	.09
	Min–max	0–4	0–3	0–4	0–2					
AM	*M* (*SD*)	1.6 (1.3)	1.5 (1.0)	1.7 (1.1)	1.5 (1.1)	Word class	1, 57	0.09	.76	.002
	Min–max	0–4	0–4	0–5	0–4					

Note. AM = age-matched; SLI = specific language impairment; LM = language-matched; ICON = iconic condition; ATTENT = attention-getting condition.

Figure 2. Interaction of gesture condition by group in children's depth scores.



and how well they defined them (depth) when taught with iconic gestures versus gestures that focused children's attention on the words. To start with, the learning condition had a significant effect on breadth scores. In line with our hypothesis, children of all groups defined more words correctly taught with iconic gestures, suggesting that, overall, iconic gestures more efficiently enhance lexical–semantic learning than do gestures that guide children's attention to words.

This result is compatible with previous research on lexical learning (in terms of acquiring the link between a lexical form and meaning), showing an iconic gesture advantage over mere verbal learning in SLI and TD populations (Capone & McGregor, 2005; Ellis Weismer & Hesketh, 1993; Lüke & Ritterfeld, 2014), over arbitrary gestures in TD children (Vogt & Kauschke, 2017), and over pointing gestures in TD children (Capone Singleton, 2012). Also, our results on definition abilities perfectly fit in with our previous findings on comprehension and naming of the target words: TD children as well as the children with SLI benefited more successfully from iconic gestures rather than from attention-getting gestures (Vogt & Kauschke, 2017). We demonstrated that iconic gestures provide an advantage over and above merely increasing children's attention. Although both iconic and attention-getting gestures may focus children's attention and lead to increased salience of target words, iconic gesture information prompts richer encoding and stronger links to the lexical form. This study investigated whether the beneficial effect of iconic gesture would also apply to meaning acquisition and found that iconic gestures also enhanced semantic learning. Children more efficiently took advantage of iconic gestures to establish semantic knowledge about previously unknown words.

Remarkably, however, concerning depth of semantic knowledge, the effect of condition varied across the groups such that children with SLI, but not TD children, provided more information on each word when the words had been taught with iconic gestures rather than with attention-getting gestures. TD children gave rich information on the words' meaning independent of the gesture condition. Probably, they predominantly used iconic information to establish and strengthen the link to the lexical form and to build semantic knowledge on a more superficial level but acquired deep semantic knowledge regardless of the gestures presented. Children with SLI, by contrast, exploited iconic gestures to a greater extent and made use of the visual information expressed by the gestures to both establish and consolidate semantic knowledge. Iconic gestures convey meaning in a different way than speech does (Holle, 2007). In the case of nouns, illustrations of prominent object features were conveyed by the gestures, thus helping children to build richer object representations. Concerning verbs, the gestures depicted the manner and path of the action, resulting in stronger action associations. Apparently, children with SLI realized that iconic gestures provided useful cues and used this visuospatial information for acquiring the word's meaning to a greater extent than TD children.

The results show that iconic gestures do have an impact on the development of word meaning. They provide important information that is used by children and even more by children with SLI. The finding of a differential benefit from observing iconic gestures in TD children and children with language impairment accords with previous research claiming a stronger gesture advantage in children with SLI as compared to TD peers (Botting et al., 2010) and demonstrating a gesture benefit over a no-gesture condition for pragmatic comprehension (Kirk et al., 2011; Lavelli et al., 2015). The results of this study reveal a similar pattern for word learning. TD children and children with SLI exploited iconic gestures for establishing semantic representations of new words on a surface level, but children with SLI in particular used nonverbal information provided through iconic gestures to consolidate semantic knowledge.

Effect of Word Class on Children's Responses

Another interesting result was that, regarding both breadth and depth of semantic knowledge of nouns for objects and verbs for actions, no effect of word class emerged, indicating that children defined a similar number of nouns and verbs and provided meaning information on nouns and verbs likewise. However, it has to be kept in mind that our scoring procedure accepted nonverbal (bodily) performance of the actions as adequate responses. Thereby, we assumed that semantic knowledge of which action is meant by the word exists, when the child is accomplishing the respective action. The results suggest that children establish and elaborate semantic knowledge about object and action names to a similar extent even if they might not be equally able to express this knowledge in spoken language.

Clinical Implications

This study has implications for clinical practice. Our findings suggest that children with SLI, who are known for their difficulty establishing deep and diverse semantic representations, can effectively learn the meaning of new words. This finding is encouraging as it shows that the children do have the potential to improve their semantic learning skill. Providing children with SLI with multiple, repeated, and varied exposures to a reasonable number of new words in rich and well-structured contexts, preferably in one-to-one or small group tuition, is a useful starting point. Moreover, our findings can inform intervention by showing that iconic co-speech gestures support semantic learning. Hence, therapists working with children with SLI should take into account their sensitivity to information in a visuospatial modality by introducing iconic gestures into intervention. In this way, therapists may offer an opportunity for the children to exploit iconic gestures as useful cues to support their semantic learning.

Conclusions

This study investigated learning the meaning of nouns and verbs under an iconic condition and an attention-getting co-speech gesture condition in children with SLI and TD children. We conclude that children with SLI can effectively acquire the meaning of both new nouns and verbs. Iconic co-speech gesture proved as a useful tool for TD children and children with SLI to establish initial semantic representations. However, in particular, children with SLI exploit the nonverbal information provided through iconic gestures to build deep semantic knowledge. Yet, our data do not allow for exploring *how* iconic gestures were decoded by the children. There is a need for further research to find out which mechanisms and which specific pieces of information provide the benefit.

Acknowledgments

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Erklärung

Hiermit versichere ich, dass ich die vorgelegte Dissertation mit dem Titel *Einfluss ikonischer Gesten auf das Wortlernen von Kindern mit und ohne umschriebene Sprachentwicklungsstörung: Eine Trainingsstudie* selbst und ohne fremde Hilfe verfasst, nicht andere als die in ihr angegebenen Quellen oder Hilfsmittel benutzt (einschließlich des World Wide Web oder anderen elektronischen Text- und Datensammlungen), alle vollständig oder sinngemäß übernommene Zitate als solche gekennzeichnet sowie die Dissertation in der vorliegenden oder einer ähnlichen Form noch keiner anderen in- oder ausländischen Hochschule anlässlich eines Promotionsgesuches oder zu anderen Prüfungszwecken eingereicht habe.

Frankfurt, 10.06.2017

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Unterschrift (Vor- und Zuname)